

DOCUMENT RESUME

ED 071 067

CS 000 350

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TITLE The Use of Theoretical Models in Research. Highlights of the 1965 Pre-Convention Institutes (Detroit, Michigan, May, 1965).
INSTITUTION International Reading Association, Newark, Del.
PUB DATE May 65
NOTE 148p.
AVAILABLE FROM International Reading Association, 6 Tyre Avenue, Newark, Del. 19711 (\$1.25 non-member, \$1.00 member)
EDRS PRICE MF-\$0.65 HC-\$6.58
DESCRIPTORS *Learning Theories; *Models; Motivation; *Reading; Reading Research; *Scientific Methodology; *Theories; Vocabulary
IDENTIFIERS General Open Systems Theory; Integrated Functional Learning Theory; Substrata Factor Theory

ABSTRACT

Three papers are presented and each is followed by two reactions. The first paper presents methods of dealing with questions about the conduct of scientific theorizing. The theory-models approach is explained as a mode for conducting part of the theory construction tasks required in the complete act of scientific inquiry. In the second paper a summary of research on reading acquisition is presented to demonstrate the importance of integrated-functional learning theory in dealing with human behavior. The third paper presents fundamental postulates common to the General Open Systems Theory and the Substrata-Factor Theory. Hierarchical working systems are noted for content areas. The sequential proration technique is seen as possibly providing a basis for determining the extent of a particular subsystem's impact on the suprasystem. Diagrams and references are included. (This document previously announced as ED 028 905.) (RT)

ED 071067

HIGHLIGHTS

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of the

1965 Pre-Convention Institutes

Detroit, Michigan

May, 1965

Brother Leonard Courtney, F.S.C.
General Chairman and Editor

INSTITUTE V USE OF THEORETICAL MODELS IN RESEARCH



International Reading Association
Newark, Delaware

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FOREWORD

The Tenth Annual Convention of the International Reading Association was held in Detroit, May 5-8, 1965. For the first time, the regular convention program was preceded by a series of specialized Institutes, each devoted to a specific area or problem current to the field of reading. These Institutes attracted almost five hundred persons, most of whom were intimately concerned with daily professional involvement with current issues - specialists and experts interested in studying leisurely, but intensely, the emerging aspects of their work and exchanging views, procedures, and solutions with other specialists.

The following six Institutes were offered in 1965, each ranging from two to four sessions:

- I. The Culturally Deprived Reader
Chairman: Charlotte K. Brooks,
District of Columbia Public Schools
- II. The Role of the Reading Consultant
Chairman: Dorothy M. Dietrich, Union
Free School District, Uniondale, New
York
- III. Some Administrative Problems of
Reading Clinics
Chairman: Albert J. Harris, City
University of New York
- IV. Neurological and Physiological
Contributions to Reading
Chairman: N. Dale Bryant, State
University of New York at Albany
- V. The Use of Theoretical Models in
Research
Chairman: Albert J. Kingston
The University of Georgia
- VI. Linguistics and Reading
Chairman: Priscilla Tyler, University
of Illinois

At the luncheon, held for all participants of the six Institutes, Nila Banton Smith, Past-President of IRA, presented an address which succinctly traced the separate threads of research involving each of these divergent issues. Dr. Smith's address provides an admirable introduction to the collected papers from the Institutes which have been published by the Association in a series of five separate pamphlets entitled Highlights of the 1965 Pre-Convention Institutes. These selected papers include many stimulating materials from the various meetings.

David Gottlieb examines the challenge of socially alienated youth, the trends and patterns in modern society which are conducive to difficulties in scholastic adjustment. Ida Kravitz draws from her own personal experience to offer measures by which reading specialists may meet the special needs of the "socially alienated" youth.

H. Alan Robinson considers the various roles of the reading consultant in the modern school, K-12: the consultant as resource person, advisor, in-service leader, investigator, diagnostician, instructor, and evaluator. Dorothy Dietrich has expertly supplemented this position paper with her editing of the discussion from the participants' specific and practical views on the subject.

Three papers focus on the daily administrative problems of the reading clinician. Two papers consider the reading clinic as training center. George Spache examines the University Reading Clinic in its various roles of teacher-training, staff-training, service and research with the difficulties and handicaps which tend to dilute complete effectiveness. Caroline Stubblefield studies the wealth of opportunities available to the Public School Reading Clinic as a training center. Based on several fascinating case studies, Bruce Balow offers five principles of behavior toward effective liaison with specialized diagnostic and treatment resources.

The several papers from the specialized Institute on "Use of Theoretical Models in Research" examine the basic conceptions, learning principles and theories which affect experimental techniques, not only in reading but in psychology and education generally. Finally, a joint Institute on "Linguistics and Reading," co-sponsored by the International Reading Association and

the National Council of Teachers of English, considered in depth the interrelationship of these two fields. Some of the papers from this Institute have already appeared in other journals, but the selection presented "highlights" the current investigatory bent involved in language, its components, and the mutual responsibility of linguists and reading specialists for integration and application of these ideas.

These few papers cannot adequately represent the total impact of the First Annual IRA Pre-Convention Institutes, nor convey the work and organization which went into them, and the stimulation, challenge, and practical satisfaction which derived from them. It is hoped, however, that this sampling will provide some of the flavor.

Brother Leonard Courtney, F.S.C.
General Chairman

MILESTONES IN THE DEVELOPMENT OF SPECIALIZED INTERESTS IN READING

by

Nila Banton Smith

During IRA's Pre-Convention Institutes, participants studied correlates of reading in six specialized fields. Each of these specific areas has its own fascinating story of growth in regard to its interest in reading. Let us step from one milestone to another as we follow the development of these interests. The milestones are widely-spaced in time periods and mark divergent pathways.

Reading Clinicians

My first acquaintance with the term "remedial reading" was through an article by W. L. Uhl, published in The Elementary School Journal, December 1916. Early investigators used such terms as "reading inferiority," "reading deficiency," and "reading disability." It was not until the Nineteen-Twenties, when the schools took over the problems of disabled readers, that the term "remedial reading" came into general use.

The first milestone in the development of reading clinics was laid by Grace Fernald at the University of California, Los Angeles. Dr. Fernald, who previously had been working with deficient readers, was given a room in the University Training School in which to diagnose and treat the reading retarded. From this developed the "Clinic School," the beginning of reading clinics.

The second milestone was reached in the early Thirties as indicated by William S. Gray in 1935:

Because the needs of many poor readers cannot be determined readily through classroom diagnosis, institutions and school systems in increasing numbers are establishing educational clinics. These clinics are rendering very valuable service as shown by the work of Baker and Leland in Detroit, Betts in Shaker Heights, Ohio, and Witty at Northwestern University.¹

¹William S. Gray, Journal of Educational Research, Vol. 28 (Feb. 1935), p. 410.

During the next seven years, a new high was reached in the establishment of reading clinics in public school systems. This growth is reflected in a heading which appeared in the Education Index. The topic of "Reading Clinics" had become so popular, and articles concerning them so numerous, that in 1942 Reading Clinics was given a separate heading in this Index under the general heading of Reading.

During the Forties, there was extended interest demonstrated by reading clinicians who worked cooperatively with the other disciplines, particularly in diagnosis.

By 1965 a new milestone had been laid by the many organizations to provide reading services variously called reading clinics, reading centers, reading laboratories, reading institutes, reading improvement services, etc. While such organizations have increased numerically, their functions have been extensively diluted, in many cases, so that their work is far removed from the original concept of a clinic. Hopefully, participants in the clinical Institute have set up some standards to differentiate clearly between organizations worthy of being considered as clinics and many others now operating on tenuous and unsubstantiated bases.

The Role of the Reading Consultant

The Role of the Reading Consultant, although a relatively new topic, is rapidly laying additional milestones.

The first supervisors in the public schools were those in charge of special fields: music, drawing, physical education, manual training, domestic science, and handwriting. Their employment grew rapidly between 1880 and 1915.

During the years 1915 - 1925, there was considerable discussion concerning the supervision of basic subjects in the elementary curriculum. While much of this attention was directed toward the need for principals to supervise instruction, some supervisors were appointed for general supervision of elementary school subjects. Perhaps, this was the first milestone.

The second milestone, concerned with supervision in reading, was the impetus given to such a provision by the Thirty-Sixth Yearbook, Part I of the National Society for

the Study of Education. An entire chapter in this yearbook was devoted to "The Reorganization and Improvement of Instruction in Reading through Adequate Supervision." It outlined the supervisory program in reading and expressed the need for supervisory services in reading at all school levels.

The third milestone was the first research concerned with the role of the reading consultant: Kathryn Dever's Positions in the Field of Reading, 1956 and H. Alan Robinson's An Occupational Survey of Reading Specialists in Junior and Senior High School, 1957. These researches marked a new epoch. For the first time, different kinds of specialized positions and the duties were revealed in the field of reading.

The fourth milestone was a chapter in the Sixtieth Yearbook of the National Society for the Study of Education in which Gray recommended programs of special courses as preparation for the position of "Supervising Reading Specialists."

And the fifth milestone was reached when seven states agreed to require certification for reading specialists. The supreme milestone will have been reached when all states have such a requirement.

Neurological and Physiological Aspects of Reading

The area of Neurological and Physiological Aspects of Reading deserves special esteem. Reading interests in this discipline antedated all others. The medical men were the first in the specialized disciplines to become interested in reading. The initial milestone was marked in 1896 by the publication of an article by W. P. Morgan in the British Medical Journal, "Congenital Word Blindness." In all of the many reports during the next 15 years, the medics assumed that congenital word blindness, or congenital alexia, was the cause of reading retardation. Other laboratory studies, physiological in nature, also were conducted. These involved eye-movements, visual perception and inner-speech.

A second milestone was reached at about 1915 when the psychologists challenged the word-blindness theory. They suggested a broader range of causes of reading disability and involved other psychological and physiological factors.

Increasing contributions were made from 1920 to 1950 in regard to the hygiene of reading, visual defects, reversals, dominance, and relationships between intelligence and reading. It was during this period of advanced study and speculation that Orton expounded his theory of cerebral dominance and Fernald experimented with the kinesthetic method.

This present decade brought greatly increased and extended studies of brain damage, mental retardation, the sensory deprived, aphasics, perceptual ability and sex differences. Experiments based on new neurological-physiological theories have been expounded: Smith and Carrigan's synaptic-transmission theory, Delacato's neuro-psychological approach, Burk's attempt to provide medication for the brain-damaged, and Staiger's administration of a psychic energizer to disabled readers. All these studies indicate that those interested in neurological and physiological factors continue to search for solutions to reading problems.

Linguistics and Reading

Linguistics and Reading is a recent topic that is attracting much attention. The science of linguistics, of course, is a very old one. It is only recently, however, that attempts have been made to apply this science to the teaching of reading.

My first research of linguistics, as applied to reading, encompassed a book titled Linguistics in Education, by M. V. O'Shea, published in 1927. Chapter VII, "Acquiring of Word-Ideas in Reading," places much emphasis upon "language unities in teaching reading" and "learning the function of literal symbols."

The first real milestone, however, was an article by Leonard Bloomfield in Elementary English Review 1942, which discussed the direct application of linguistics to reading.

The next milestone was the recognition of possibilities by the leaders of IRA and NCTE, two large professional organizations, who appointed a joint committee on reading and linguistics. This committee has been very actively engaged with related problems in the two fields.

The first five years of the Sixties marked another milestone with the appearance of professional publications. Two books were published: Fries' Linguistics

and Reading and LaFevre's Linguistics and the Teaching of Reading. In 1961, the first children's book, based on linguistic principles, was published: Let's Read by Barnhart and Bloomfield. Other sets of material for first-grade pupils have appeared recently and an entire series of linguistic readers is soon to be published by Fries with collaborating authors.

This wide publication of linguistics materials, as applied to the teaching of reading, certainly marks an epoch of development in this discipline.

The Culturally-Deprived Reader

The Culturally-Deprived Reader is a topic that does not have a long history. A few philosophers in Europe talked about "educating beggars to live like kings," but we haven't heard much about this in our country until recently.

The establishment of the readiness concept between 1925 and 1930 for the culturally-deprived was the first milestone for American schools in the reading field. Surveys and statistical studies at this time yielded decisive evidence that all children were not ready to begin reading in the first grade; pupils from culturally-deprived homes were found to be particularly lacking in this qualification. Hence, reading instruction was often delayed for a year or perhaps two years while teachers attempted to develop their pupils physically, mentally, socially, experientially and linguistically. This was an excellent start in the right direction.

Recently, a second milestone was laid by the public schools in cities like New York, Los Angeles, Detroit and others which initiated experiments and special effort to meet the needs of culturally-deprived young children before reading and after beginning to read.

A momentous milestone was laid when President Johnson declared war on poverty in 1964 and embodied the goal of educating our poverty-stricken people. With financial aid from the government, enriching pre-school experiences can be provided. In many places, more books and materials may be purchased; better trained teachers will be available; additional research will be stimulated. The whole educational world is excited about possibilities in this area. With this wealth of interest, effort, and creative thinking, reading instruction as

well as other aspects of education should show marked improvement. It is a great day for the culturally deprived!

The Use of Theoretical Models in Reading Research

Finally, I shall discuss The Use of Theoretical Models in Reading Research. This topic leads to a delineation of milestones in the progress of research techniques in reading.

The earliest research in reading consisted of laboratory studies without specific designs or controls, and without need for statistical computation.

A significant milestone was laid with the emergence of the scientific movement in education. Between 1910 and 1920 the first standardized tests were developed; the first statistical procedures for treating test data were devised. Early studies which used these tools, however, were crude in delimitation of topic, design and statistical treatment. The latter usually consisted of only the simple techniques of finding central tendencies, and perhaps computing correlations.

Between 1925 and 1950, research showed marked improvement. The topics were more basic and more sharply restricted; experimental techniques were improved, and interpretation became more discriminating. There was still much to be desired, however, in advancing the quality of reading research.

Throughout this period, loud and frequent criticisms of research in reading were voiced. As an example, Scott's critical review of reading research, conducted between 1940 and 1950, characterized this research as "voluminous," "fragmentary and unrelated", "varied as to underlying concepts," "practical rather than theoretical," oriented toward content methods and mechanics," "varied in quality," and "in importance," and "inconclusive and limited." He added that the "most tantalizing and stimulating characteristic of reading research findings is their inconclusiveness."

As for the future, Scott reported, "with proper tending, pruning, and thinning the contributions of research in reading can be greatly enhanced." *In spite of* his criticisms, Scott stated finally that research in reading, "has contributed much to the welfare of readers

and to the skill of those who teach them."²

It seems that since the time of Scott's criticism we have been "tending, pruning and thinning," and, currently, laying another milestone.

In 1962 Harris stated at the end of his "Summary of Investigations Related to Reading:"

Research related to reading in the previous year shows several promising trends. A number of investigations revealed great care in experimental design to control significant variables. Thorough and scholarly analyses of related research accompanied others. A willingness to examine intensively the significant learning processes in reading was likewise evident . . .³

In 1964 Holmes and Singer made these statements in regard to reading research:

A review of research during the past three years makes it clear that the profession is searching not only for ways of ordering the meanings behind objective data collected and relationships calculated in the past, but also for more fundamental data and deeper meanings underlying first interpretations.

Recognition of the need to search for "undermeanings" is evident in concerted efforts (a) to construct new models that will more faithfully than previous models represent the processes at work in the subsystems or casual chains of events that come to focus in the reading act and (b) to probe deeper with studies that aim to explain reading phenomena in smaller and smaller units.

²Winfield C. Scott, "A Forest View of Present Research in Reading," Educational and Psychological Measurement, Vol. XIV (Spring 1954) pp. 208, 14.

³Theodore L. Harris, "Summary of Investigations Relating to Reading," The Journal of Educational Research, Vol. 55 (Feb. 1962), p. 210.

And finally the same authors stated:

. . . The present analysis reveals that, during the period from September 1960 through September 1963, at least three new and exciting trends are clearly discernable: (a) a concerted effort at theory building (b) a greater concern for designs that are experimentally and statistically sophisticated, and (c) a host of new instruments and techniques.

A field of study is generally headed for a spurt of creative productivity when theory construction and experimental research become closely interdependent and mutually directed.⁴

In the light of these evaluations and others by well-qualified professional people, it would appear that this period is one of marked progress in improving the quality of reading research, and that we have reached a new milestone in this important area of specialization.

I have attempted to cover some of the major milestones in each of the six specialized areas studied during the Pre-Convention Institute. I should like to conclude by expressing gratitude to those who are working in these special fields. You are to be congratulated for your interest in reading and your valuable contributions. Cooperative effort is a trend of much promise. May you continue to lay many more milestones, creatively and constructively and within ever shorter time-intervals.

♦♦

⁴Jack Holmes and Harry Singer, "Theoretical Models and Trends Toward More Basic Research in Reading," Review of Educational Research, Vol. 34 (April 1964), pp. 127-55.

THE USE OF THEORETICAL MODELS IN
RESEARCH IN READING

Edited by

Albert J. Kingston

The University of Georgia

Introduction: Current Interest in the Concept of Model
in Scientific Research.

Albert J. Kingston

The Model in Theorizing and Research

Elizabeth Maccia
The Ohio State University

Discussion of Dr. Maccia's paper

Jack Holmes
University of California

Frederick B. Davis
University of Pennsylvania

Integrated-Functional Learning Theory and Reading

Arthur Staats
University of California

Discussion of Dr. Staats' paper

Harry Singer
University of California (Riverside)

Edward B. Fry
Rutgers University

General Open-Systems Theory and the Substrata Theory of
Reading

Martin Kling
San Francisco State College.

Discussion of Dr. Kling's paper

Dr. Alton Raygor
University of Minnesota

Dr. Donald E. P. Smith
University of Michigan

Selected References to Models in Research.

INTRODUCTION

The complexity of the reading process has been recognized by researchers and classroom teachers alike. During the past two decades the reading process has been examined from a myriad of viewpoints which range from instructional methods to elaborate systems of factor analysis. In the course of such explorations reading ability has been correlated with most of the human characteristics we are able to list as well as many of the environmental forces in which the human organism functions. Such studies have served both to intrigue and to frustrate. They intrigue because they prove the complexity of reading behavior, but they also frustrate because often many more questions are raised than are answered.

Yet reading is not the only discipline which faces such a dilemma. At present psychologists are facing similar problems in their explorations of human learning, intellectual functioning, personality and mental illness. Sociologists and social psychologists encounter analogous difficulties in their studies of human relationships. Medical scientists, bio-chemists and physicists also face this type of difficulty. A major problem all these scientists face is that of formulating adequate theories to explain the complex phenomena they observe. Such theories are necessary for they serve as the bases for further study and research. Theories, of course, must be constructed in the light of what is already known, and regardless of the discipline the first step in theory building must be to delineate what is scientifically "known." It often is difficult to distinguish what we really "know" from what we "infer" or "believe." Generally we must admit that we tend to confuse knowledge with value-judgments and beliefs. Again we have a problem with our nomenclature and wonder whether our choice of terms is adequate for describing the complex phenomena we seek to explicate. In reading, for example, does the term "reading rate" or "speed" adequately describe the process of visual discrimination and symbolizations of ideas required in the reading? Does the term "comprehension" adequately describe the process by which a reader derives meaning from a printed passage? Probably these terms are no more adequate than the use of the word "intelligence" to describe the range of intellectual functioning the human performs, or the word "concept" to describe the meanings a child derives from a vivid personal experience inside or outside of the

classroom, or the word "personality" to describe a person's affective components.

Similarly one must question whether our methods and tools of measurement and description are adequate to enable us to understand so complex a phenomenon as reading. Do our present tests and measures provide sufficiently valid and reliable samples of reading behavior so that we can put faith in a technique of teaching which yields statistically significant differences in pre- and post-test scores? Should we be amazed to discover that currently used tests can be factor-analysed so that they reveal other more fundamental components underlying the abilities measured by these instruments? Should we be surprised to discover that reading is related positively or negatively to other aspects of human behavior? Obviously not, if we truly understand that in any human action the total organism is involved. Yet much of the present research in reading seems to be focused on verifying these relationships.

In an effort to break through such problems, scientists have attempted to build theories which describe the complex behavior they observe. Often they attempt to explicate the phenomena under scrutiny by the construction of "models." Such models may help the researcher to understand more completely the underlying relationships between the various components of the phenomena. Furthermore, they may enable the researcher to control certain factors while studying other factors in order to discover the way in which the various parts function. For many the model represents a simplified version that can be more readily understood and studied. Models may be merely diagrams, mathematical formulae or actually three dimensional representations. The form is not so important as the faithfulness with which it reproduces the phenomenon it models. Obviously erroneous or overly simplified models can be misleading. However, carefully developed models can be a great boon to the researcher in designing and conducting experiments.

The papers in this symposium represent a pioneer attempt to explore the concept of model with a view toward examining some of the possibilities of using theoretical models in reading research. All of the papers were prepared for and presented at the pre-conference institute held in conjunction with the 1965 Conference of the International Reading Association. The program was arranged as follows:

Dr. Elizabeth Maccia, a philosopher of science introduced her paper "The Model in Theorizing and Research." Dr. Jack Holmes and Dr. Frederick Davis responded to this paper with particular emphasis on the extension of the possibilities for research in reading. Dr. Arthur Staats, a psychologist, described an experiment based upon an operant-conditioning model. Dr. Harry Singer and Dr. Edward Fry responded to this paper. The third major paper was delivered by Dr. Martin Kling, who attempted to relate the substrata factor theory model to open systems theory. Dr. Alton Raygor and Dr. Donald E. P. Smith responded to the paper. The symposium was organized and chaired by the writer and all of the papers are presented in this publication in the order in which they were read at the meeting. Unfortunately, it was not possible to include in this report the valuable discussions which ensued between participants and those attending the session. The lively discussion following each paper gave evidence of the interest and stimulation generated.

A brief list of references also has been included for the benefit of those who wish to pursue the study of "models" in some detail.

Albert J. Kingston
The University of Georgia

THE MODEL IN THEORIZING
AND RESEARCH

Elizabeth Steiner Maccia
Ohio State University

Purpose

Educational theorizing is no longer rejected as mere speculating. In fact, it has been singled out as a critical need and a trend in research activity. With respect to reading, see the review of research that appeared last year.¹ Therein, Carroll called once more for a comprehensive theory of language behavior^{2,3}. Two years earlier, he had called for such a theory to meet a critical need.⁴ Also in the review, Holmes and Singer discerned "a concerted effort at theory building" as one of the new and exciting trends in reading research.⁵

Even though educational theorizing is considered necessary and there is an effort to theorize about it, little consideration has been given to questions concerning how one goes about theorizing. Instead, research methodology is restricted to scientific⁶ verification procedures. Today, for an endeavor to be given the honorific title, 'research', it must include data collection.

In this paper, I intend to present some of the results of our attempts to deal with the neglected questions about theory construction. The results will be those centering on the model.⁷

Researching and Theorizing Are Related: Earlier I thought it possible, like Humpty Dumpty, to make words do what it would be better for them to do rather than do what tradition would have them do. The phrase 'scientific researching', would do a better job if it were stretched to include theorizing as well as verifying.

. . . theory construction is a phase of research. Men who do it do research. Logicians, mathematicians, theoretical scientists, and laboratory scientists are all researchers.⁸

From the stretching of 'scientific researching,' the stretching of 'scientific research methodology' to include the methods of theory construction followed.

At the time, the thought of this possibility seemed conservative. I had not attempted to stretch 'researching' to include the nonscientific modes of inquiry. For example, I had not claimed that philosophizing was researching. Now, this possibility appears radical. We are more tradition-bound than I imagined. Consequently, I shall not attempt to talk of scientific research as if it included theory construction. Instead of the complete act of scientific research, I shall talk of the complete act of scientific inquiry. Instead of scientific research methodology, I shall talk of the conduct of scientific inquiry.

Inquiry, whether it be scientific or not, is directed toward knowledge production. What the inquirer strives to attain are cognitive claims which can be shown to be adequate. The complete act of inquiry, therefore, has two main dimensions: the development of cognitive claims and the justification of cognitive claims. The conduct of inquiry, therefore, involves one in modes of constructing cognitive claims and modes of checking cognitive claims.

If an inquiry is scientific, it includes development of a hypothesis or hypotheses about reality. A hypothesis is a not-yet-checked claim about relations between aspects of reality, and these relations are asserted to extend beyond a given time and given place. A hypothesis takes the form of a generalized proposition, a statemental assertion of a relation between classes (variables). A hypothesis or hypotheses must be in the context of other hypotheses. A single unrelated hypothesis or a heap of unrelated hypotheses offers no cognitive claim. Knowledge is adequate theory, and theory is a set of related hypotheses. It is patent, consequently, that the development of cognitive claims in science is theory construction.

If an inquiry is scientific, it also includes justification by means of observations of instances falling under the hypothesis or hypotheses. Indicators of the variables must be specified, so that the variables can be observed in each instance. For example, an indicator of reading readiness is a portion of the Metropolitan Readiness Tests. Furthermore, the arrangement to

produce the readings of indicators (a design for data) must be set forth. Solomon Four Group Design is, of course, an illustration of an arrangement which is experimental in nature. Different designs give different plausibilities with respect to hypotheses. This plausibility enters into the interpretation of the data. Ascertainment of the generality possible from the instances checked is of primary importance here. Clearly, justification of cognitive claims in science is theory verification.

Schema 1 presents the complete act of scientific inquiry, and, therefore, the relation between researching (data collection and interpretation) and theorizing. The schema separates the tasks of verification (researching) from tasks of theory construction (theorizing). In doing one, however, must take the other one into account. Theorizing must be adjusted to verification procedures. Conceptual systems which cannot be brought into correspondence with indicators and designs are useless. Concepts without percepts are empty. On the other hand, verification procedures must be adjusted to theorizing. Verification procedures which cannot be brought into correspondence with variables and their relations are useless. Percepts without concepts are blind. Even though interdependence is a fact, should theoretical and methodological inquiries be restricted if they go beyond one another? Should not the fact that adjustment lacks a dynamic quality be taken into account before one automatically answers in the affirmative?

1. Development of Cognitive Claims: Theory Construction Tasks
 - 1.1. Setting Forth Terms (Variables)
 - 1.2. Relating Terms (Variables) to Form Propositions (Hypotheses)
 - 1.3. Relating Propositions (Hypotheses) to Form Theory
2. Justification of Cognitive Claims: Theory Verification Tasks
 - 2.1. Collection of Data
 - 2.1.1. Specification of Indicators
 - 2.1.2. Specification of Design
 - 2.2. Interpretation of Data

SCHEMA 1: THE COMPLETE ACT OF SCIENTIFIC INQUIRY

The Model in Scientific Inquiry

A model is an object or a characterization used either to represent or to be represented. When an object or characterization is used to represent, it is a model of; when used to be represented, a model for. A model of is called a representational model; and a model for, a non-representational model. In scientific inquiry, the characterizations of interest are generalized propositions which set forth relations between aspects of reality. The characterizations, thus, are empirical in nature. All propositions, whether they be empirical or not, have form. That is to say, the proposition is structured in a certain way (the terms are interrelated in a certain way) and the group of propositions is structured in a certain way (the propositions are interrelated in a certain way). The characterizations, thus, are also formal in nature. The content can be taken from an empirical characterization, and the remainder would be a formal characterization¹⁰. Schema 2 summarizes and illustrates the kinds of models discernable in a scientific context. The illustrations are given in terms of language behavior of which reading is a part.

1. Representational

1.1. Object :a programmed computer used to represent an aspect of language behavior, i.e. simulation of actual language behavior through a programmed computer

1.2. Characterization

1.2.1. Empirical :propositions about language behavior used to represent the actual language behavior, i.e. theory of language behavior

1.2.2. Formal :the formal component of the propositions (the way in which the terms and propositions are interrelated) used to represent the actual interrelations of aspects of language behavior and related events, i.e. the

formal component of theory
of language behavior

2. Non-representational

2.1. Object :a programmed computer used
to be represented in
language behavior

2.2. Characterization

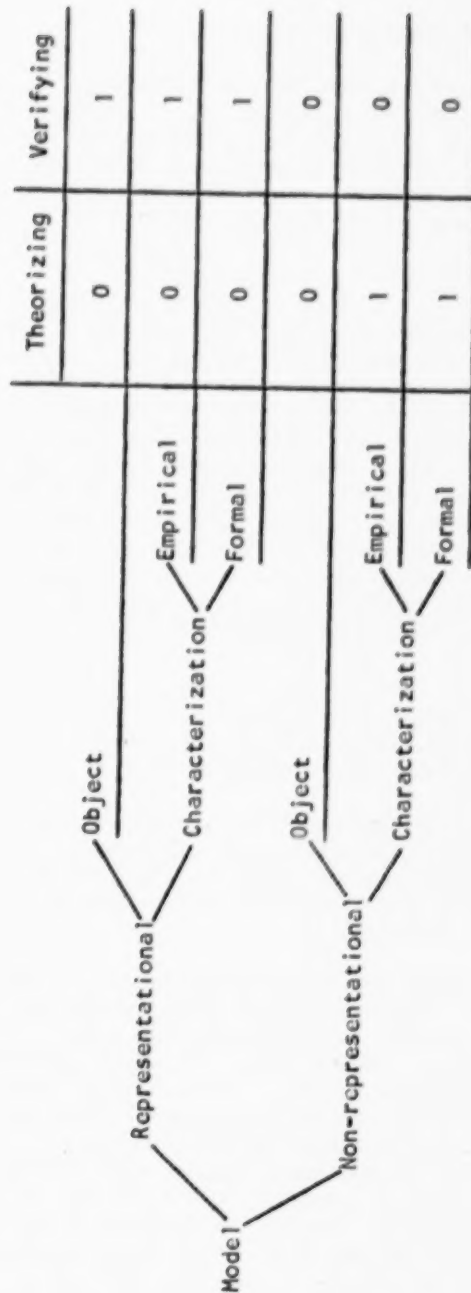
2.2.1. Empirical :propositions characterizing
messages when they are taken
to be outputs of a Markov
process used to be represent-
ed in a theory of language
behavior

2.2.2. Formal :Markov process used to be
represented in a theory of
language behavior

SCHEMA 2: KINDS OF MODELS AND ILLUSTRATIONS

Not all kinds of models discernable in a scientific context are of significance for scientific theorizing. Some kinds may be of no significance for scientific inquiry, and some kinds may be of significance only for scientific verification. Schema 3 indicates the significance of the various kinds of models for scientific inquiry.

Non-representational objects are of no significance for scientific inquiry, but representational objects are. It is through objects formed to represent instances that theory which could not be verified becomes verifiable. Unavailable instances are overcome by simulation. Also of significance for verification procedures are representational characterizations. Models of data, e.g. Gaussian distribution, are essential in collection and interpretation of data¹¹. Representational characterizations are of no significance for theorizing. In theorizing, characterizations must be developed. Characterizations from which to devise characterizations are what is needed. Models for (non-representational models) are required.



'1' denotes significance

'0' denotes no significance

SCHEIA 3: KINDS OF MODELS AND THEIR SIGNIFICANCE FOR SCIENTIFIC INQUIRY

The Theory-Models Approach

The conclusion that only non-representational models of the characterization kind are significant for scientific inquiry led to the formulation of the theory-models approach. The theory-models approach is a mode for conducting part of the theory construction tasks required in the complete act of scientific inquiry.

The theory-models approach is not inductive. One does not begin with observable data and work toward a group of precise and systematic characterizations; a theory. It is not possible to develop theory inductively. In a scientific inquiry, theorizing must precede researching. Nature cannot be approached in an empty-headed fashion. Data must be collected and one must know which data are relevant. Because one does not make the hypotheses of the investigation explicit until after data collection, or because one makes only one or two hypotheses of the theoretical context explicit, it is thought that the data dictate the theory. This thought is expressed in scientific papers. Medawar has asserted that this expression has made the scientific paper fraudulent:

The scientific paper in its orthodox form does embody a totally mistaken conception, even a travesty, of the nature of scientific thought.¹²

Other consequences of this thought having significance to the conduct of scientific inquiry are inadequacy in data collection and interpretation, due to the failure of rendering the implicit explicit, and inhibition of the growth of adequate theory.

When one does not have or cannot find in the literature characterizations or theory which might describe or explain the events of concern, then one must devise a theory from other theories. Obviously, the theoretician can utilize only theory known to him. Theorizing, therefore, is limited in terms of one's background. But one can set out to intellectually roam the disciplines, if one does not have, in his background, theory that could be used to devise the desired theory. The approach is essentially interdisciplinary, but it is not simply a matter of taking theory from one discipline into another. The theory-models approach is not reductive. If one starts, for example, with physiological theory, and if one is attempting to construct a theory of language

behavior from this physiological theory, then the approach is not to make the physiological theory the theory and so reduce language phenomena to physiological phenomena. Do Smith and Carrigan take a reductive approach in their neurochemical theorizing about behavior?¹³ I think not. What I take them to be doing is relating physiological variables to language behavior variables, rather than reducing language behavior variables to physiological variables. Consider a relationship such as the amount of acetylcholine and the rate of reading.

The interdisciplinary nature of the theory-models approach, moreover, does not make it a deductive approach to theorizing. In the intellectual roaming of the disciplines, the search is not for a discipline of which one's own discipline would be an instance. To state the matter differently, one does not search for a theory in another discipline from which the theory in one's own discipline can be deduced. Does Fries take a deductive approach in his theorizing about reading in the light of linguistics?¹⁴ I think not. To illustrate, what he has to say about practice is not deducible from linguistics.

The theory-models approach, rather than being either reductive or deductive, is retroductive. One does not simply take theory for theory. Theory is used as a model for theory. In forming the theory model, elements from the theory are selected and arranged. The elements may be modified in any way required for a point of view which will lead to the devising of adequate theory. From the theory model, one devises the theory. It is important to note that there is no a priori way of determining whether a theory model will produce an adequate theory, just as there is no a priori way of determining whether a theory is adequate. The theory model must be tried out. Just as theorizing should be done in a context of data, so theory model forming should be in the context of theorizing. This process of devising is called retroductive, since the theory that is devised (conclusion) contains more than the theory model from which it was devised (premises). The implication, therefore, can only lead back from conclusion to premises. Schema 4, below, summarizes the theory models approach to educational theorizing.

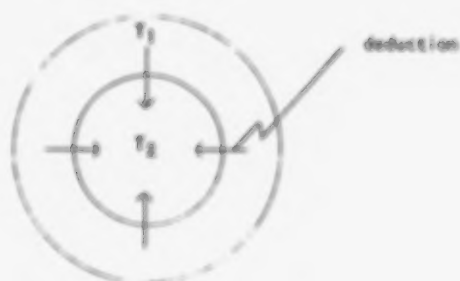
Other Theory model formation → Theory Model retroduction → Educational Theory

Schema 4: The Theory Models Approach to Educational Theorizing

Schema 5 presents a comparison of approaches to scientific theorizing.



Reductive Approach



Deductive Approach



Retroductive (Theory Models) Approach

[T_1 denotes theory from which T_2 , the wanted theory, is to be obtained.
 T_m denotes the theory model. T_1 and T_2 , of course, are equivalent only in the reductive approach.]

SCHEMA 5: COMPARISON OF APPROACHES TO SCIENTIFIC THEORIZING

Conclusion

The results of our attempts to deal by means of models with questions about the conduct of scientific theorizing are before you. Before I turn these results over for your conclusion, let me make a final point. On the basis of Holmes and Singer's review¹⁵, for most reading theorists, the expression 'theory-model' would contain a redundancy, since a theory is taken to be a model insofar as a theory represents (is a model of) some aspect of reality. This identification of theory and model which is rooted in the representational sense of 'model' leads to a disregard of the approach to theory construction in which one theory is a model for another theory, but is not the same as the theory for which it is a model. Unless models are considered as a source of theory, they cannot function in theory construction.

NOTES

1. Review of Educational Research: Language Arts and Fine Arts, Vol. 34, No. 2, April 1964.
2. I take reading to be one kind of language behavior. Other major kinds would be writing, listening, and speaking.
3. John B. Carroll "Linguistics and the Psychology of Language," Review of Educational Research: Language Arts and Fine Arts, op. cit., pp. 123-124.
4. John B. Carroll. "The Critical Need in the Study of Language," College Composition and Communication, Vol. 13, October 1962, pp. 23-26.
5. Jack A. Holmes and Harry Singer. "Theoretical Models and Trends Toward More Basic Research in Reading," Review of Educational Research: Language Arts and Fine Arts, op. cit., p. 150.
6. Throughout this paper, 'scientific' is not taken in its more precise, restricted sense, i.e., as characterized through an analysis of physics.
7. In part, these results were supported by the Cooperative Research Program of the Office of Education, U. S. Department of Health, Education, and Welfare under Projects 1612 and E-022. Project 1612: The Construction of Educational Theory Models is completed, while Project E-022: Development of Educational Theory Derived from Three Educational Theory Models is in progress.
8. Elisabeth Steiner Maccia. "The Complete Act of Research," The Graduate School Record, The Ohio State University, Vol. 14, No. 3, Spring 1961, p. 10.
9. The use of 'adequate' rather than 'true' indicates my acknowledgment of the probable nature of truth.
10. As is apparent from their naming, the formal sciences, logic and mathematics, consist only of formal characterizations.
11. Patrick Suppes. "Models of Data," Logic, Methodology and Philosophy of Science, ed. Nagel, Suppes, and Tarski, Stanford University Press, Stanford, California, 1962, pp. 252-264.

12. P. B. Medawar. "Is the Scientific Paper Fraudulent?" Saturday Review, August 1, 1964, pp. 42-43.
13. Donald E. P. Smith and Patricia M. Carrigan. The Nature of Reading Disability, Harcourt, Brace and Co., New York, 1959.
14. Charles C. Fries. Linguistics and Reading, Holt, Rinehart and Winston, New York, 1963.
15. Holmes and Singer, op. cit.

THE THEORY-MODEL APPROACH

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I have been asked to comment on Dr. Maccia's (1965) paper on the use of the theory-models approach, and, if possible, to relate her method to the way in which I actually formulated the substrata-factor theory. Let me make my position clear at the outset. I am intrigued with her idea of making explicit that which has always functioned as an intrinsic bridge in the process of scientific theory building--that is, the process of contriving, from theories in other fields, a rough or preliminary model which can then be used as a touchstone to give direction to the imagination in its creative endeavor to construct a new theory which will explain certain observed relationships and inconsistencies in one's own field.

Although I am intrigued with the idea of formalizing theory model building, I can detect a number of pitfalls in superficially roaming through other disciplines in search of a theory which may act as a model from which to construct a new theory. My concern is with the possibility that this technique will be applied mechanically unless we carefully guard against the tendency to generate theories which give only surface explanations of observed data within a particular discipline. Such explanations run all the way from superstition to scientific theory and can often have a profound influence upon behavior.

An amusing instance which occurred many years ago at a college banquet will help to illustrate my point. After dessert, my German friend, Hans, with some show of the old country's chivalry, struck a match, lighted his own cigarette, offered the flame to me, and finally to one of the young ladies who had sat poised with her cigarette through the entire episode. At that point she verily "exploded" with indignation. "How dare you!" she sputtered. "You know the third light from a match is bad luck." Hans appeared embarrassed and claimed that this must be some kind of American superstition because in Germany everybody "knew" the third light from a match was good luck, and that this was the reason he had saved it for her! Further, he believed that it made good sense because by that time all the sulphur fumes had been

dissipated. Also, he added, this was a frugal practice in a poor country to make a match go as far as possible. Conversely, I noted I had heard that during World War I it had been discovered that if one used a match for three soldiers, it was almost always fatal because it gave the enemy snipers time to draw a deadly bead on the third man. Further, I understood that the American match companies prolonged this notion so they could sell more matches.

So, with tongue in cheek, I propose that it is bad luck to be superstitious, no matter which side you take. Seriously, however, the story alerts us to the fact that in scientific theory building, as in the formulation of public opinion, we must always be on guard lest we fall into the following types of error: (a) superficial and uncontrolled observation, (b) personal, industrial, national or racial advantage gained from a particular explanation, (c) conclusions colored by traditional prejudice, wishful thinking, preconceptions, or outmoded circumstances, (d) anthropomorphism, (e) mistaking cause for effect, or vice versa, attributing an effect to a single cause when actually many are interacting to produce it, or disregarding the dynamics of energy exchange so that the possibility of mutual and reciprocal cause and effect is never considered, and, finally (g) the uncritical use of analogy.

Theory building is indeed a creative process. Analogy, of course, is the very heart of creativity, and therefore should be the central activity of the theory-models approach. In creative thinking, at least in the sciences, the use of analogy, however, should always be a guarded process, for the scientist knows that a slick analogy tends to relieve him of explaining phenomena in his own field on their own terms. In order not to be misunderstood, however, I would also stress that normally, in science, analogy is properly used as a generator of ideas, theoretical notions, and hypotheses, but should never be used as proof.

The point here is that while Dr. Maccia is surely aware of such traps, the uncritical user of her theory-models must be warned for, at worst, this approach could easily degenerate into a sophisticated rebirth of the armchair method in psychology. My worry, of course, is that in our new concern for theory building, we do not overlook the necessity of paying careful attention to the data we wish to theorize about. In other words, it

is my considered judgment that a person should be thoroughly steeped in the literature of his own field before he explores other fields to find a theory-model which will help him explain phenomena not satisfactorily explained by existing theories in his own field. Likewise, the usefulness of different types of models is dependent upon the degree to which one's particular discipline has advanced. It is sometimes necessary to favor one kind of activity over another; and, therefore, as a matter of degree and not principle, I would take issue with Dr. Maccia when she says, in another publication, "The way of researchers inherent in the Baconian perspective is antithetical to the theory-models approach." She then takes the Baconian method to task because (a) it gives no consideration to what constitutes a body of laws, (b) it depends on inductive logic to build and generalize laws from observed facts and simpler relations, (c) it does not formally recognize the place of the working hypothesis in scientific research, and (d) it appears that the Baconian notion of theory was merely a summarization of lower-order generalizations from which higher-order generalizations could be made.

I agree with Dr. Maccia that the Baconian method has its shortcomings. But after all, Bacon was writing in the early 1600's at a time when, as he said in his Fifteenth Aphorism, they had "no sound notions either in logic or physics of substance, quality, action, passion... much less weight, levity, density, tenuity, moisture, dryness, generation, corruption, attraction, repulsion, element, matter, form, and the like. They are all fantastical and ill defined." Furthermore, it seems to me that it is important to understand that in 1620 there simply was no large pool of sophisticated theories available to be drawn upon for theory-models. What Bacon had in mind, I believe, was to turn the scientist away from the myths and superstitions of prevailing scholastic dogma so that he might, with a clear eye, take a controlled look at nature as it really was or is. Furthermore, he saw in the experimental method a way to force a "yes" or "no" answer to crucial questions, and he was determined to call it to the attention of the world. His idea was to proceed from experiment to experiment, or from experiment to axioms, which would then point the way to new experiments. It seems to me that the idea of working hypotheses was in fact implicit in the notion of successive experiments. His major concern, however, was to convince the scientist that he should not encumber his observations by constructing first the grand design of

the universe, which had been the usual approach of the philosophers. In fact, the way I read Bacon, it seems to me that he was determined to give stature to that greatest of lessons which Galileo had bequeathed to his fellow scientists, when he said in essence, "Let's take a look."

My point then is this: The scientist must take a good look before he builds theory as well as after. It must be said, in fairness to Professor Maccia, that Galileo did not look blindly through his telescope. Indeed, he had the benefit of the pronouncement of Copernicus who said, "In the midst of all, the sun reposes, unmoving." The point is that the Ptolemaic theory, in a sense, was as good as the Copernican theory; and, as far as the church was concerned it was a better explanation of the planetary system, the movements of the planets, and the orderliness of the Julian calendar--until the telescope made it possible for Galileo to take a look. Equally important, however, is the fact that the basic reason Copernicus devised his new theory was that the old Ptolemaic theory simply did not fit the facts as he knew them. That is, the errors in the time tables which predicted the positions of the planets by reference to the fixed stars were so blatantly apparent by Copernicus's time that he felt obliged, as an astronomer, to re-examine the concept that the earth was the immovable center of the universe.

Copernicus's restatement of the Ptolemaic astronomy took some 30 years of hard work, and his conclusions were reached largely through the use of mathematics and logic rather than by direct observations. By setting the heavenly bodies in relation to the sun at their center, and by considering the earth as one of the planets, Copernicus found that he could account for all their movements better than he could by using the straight Ptolemaic theory. But what did Copernicus use as his theory-model? Well, the fact of the matter is, he used two or more models. Besides the Ptolemaic model itself, Hicetas, whom we are told lived in the fifth century B.C., had taught that the earth rotated on its own axis every 24 hours. Furthermore, Aristarchus, 200 years later, taught the same idea and added that the sun was the center of an immeasurably great universe (Schwartz and Bishop, 1958). It is apparent that Copernicus was familiar with these ideas and could have used them as his theory-models. Of course, someone will ask where Hicetas and Aristarchus got their ideas. Here we stop,

for this is like asking which came first, the chicken or the egg. So I reassert that even the theorist must be well immersed in the data of his field before he takes on the task of theorizing about phenomena in that field. This familiarity, of course, may be gained from a complete review of the literature, for the theorist could not himself perform all the experiments with which he should be familiar.

I would now like to react to the second phase of the question put to me. In short, what were my theory-models in generating the Substrata-Factor Theory on Reading? Most pertinent, I believe, was the fact that I had graduated in physiology, had taught chemistry and physics for three years, and had then worked for two years as a physical chemist on the Manhattan project. On the Manhattan project, using an enlightened Baconian experimental method, I was able to publish some ten papers on the purity of uranium and uranium compounds, four of which I understand became classified patents. After World War II, I went into the field of educational psychology, and, after reviewing some 500 experimental studies in the field of reading in 1947, I selected 40 out of a garnered list of 80 variables, each of which had a scientific claim of sorts to being (a) "the" cause or (b) an element in a list of causes of success or failure in reading. I had read an article by May Lazar (1942) in which she objected to a single-cause hypothesis, but also lamented that from the numerous lists presented by various researchers, there was no method for successfully isolating the most significant causal variable from the combination of many. In short, I overcame this limitation by combining Descartes' and Bacon's methods. Actually, my theory-model is contained in the following quote which I draw from my dissertation:

Prediction is a sound objective in the psychology of reading, because only with the ability to predict comes the ability to control--a primary objective in all science. However, reading and disabilities in reading are complicated affairs, and it soon becomes evident that the mathematically limited case of the perfect correlation

$$\phi(x,y) = 0$$

will not help much in the solution of the problem; or when the Cartesian principle is coupled with the Baconian method of experimentation, all

variables must be taken into account. Therefore...the mathematically limited case must be expanded to have a large number of relations between a large number of variables. Fortunately, in the field of statistics a symbolic expression has been set up which gives the experimenter a scientific method applicable to systems of many degrees of freedom (in the sense of n-spaced dimensions). This is the method of multiple correlation and prediction by the multiple regression equation, (Holmes, 1948).

Thus, by turning to the Wherry-Doolittle multiple correlation test selection method, I was able to extract a primary set of four variables from that list of 40 which could be thought of as the preferential variables that "best" explained the variance of power in reading in my sample of college students. I was not satisfied with my results, for I felt certain that somehow some of the other 36 variables were also important; yet, the calculations of the Wherry-Doolittle method were finished.

Although I checked and rechecked my calculations, and, therefore, was quite sure that the variables that had been selected were in fact major contributors to whatever it was that made one college student differ from another in his ability to read with power, I was unhappy because the analysis left no room for the other variables my judgment told me were also important. No existing theory or statistical analysis allowed me to structure the relationships which I felt somehow were there. However, in pondering the problem I recalled that as science advances it tends to explain phenomena in smaller and smaller units, so I began to wonder if it were not this kind of thinking that was needed here. What I needed to know was what variables were underlying these preferential variables at the secondary level and perhaps even at the tertiary level. I was aware of the complexity of the brain and further believed that the hierarchy present in its physiological structure must subsume an equally complex mental system composed of sub-systems of capabilities which must combine in orderly ways to account for such fantastically complex abilities as speed and power of reading. Furthermore, as the physical chemist is wont to analyze molecules to find atoms, and then to break down atoms into electrons and nuclei, and nuclei into the neutrons, protons, mesotrons, etc., I felt that here indeed was a rough sketch of how

to go about further analyzing my data to better account for facts as I thought I knew them. But, for the life of me, I could not quite see how to do this. In all fairness I must say that these things were in the back of my mind, but to be completely candid, I must also say that two other extremely important events took place which caused the nascent components of the substrata-factor theory to fall into place.

While teaching at Oklahoma A. and M. College, I had been working hard on my dissertation so that I might meet a particular deadline established by the University of California, the institution where I worked towards my Ph.D. Just as I had finished my analysis down to the first level, I had been called to Western Reserve University to be interviewed for a position. After arriving there I was grilled by the Psychology Department and various deans for three consecutive days and entertained royally at night. A great deal of their discussion centered on my dissertation, its findings, and their relationships to practical problems in reading. Naturally, I got very little sleep in those two nights. Hence, when I caught the plane to go back to Oklahoma A. and M., I was highly stimulated, but completely relaxed, for I had just accepted a position as Associate Professor of Psychology and Director of the Adult Reading Clinic. Apparently as soon as I boarded the plane I fell asleep only to be awakened when the stewardess announced, "Fasten your seat belts," as we began to drop down over St. Louis. In a sort of subconscious daze I looked down at the glittering lights of St. Louis and its surrounding cities. As I observed the complicated yet orderly meshing of the flow of traffic between the outlying towns and saw how it converged and flowed into and out of St. Louis, I had what Wallas called, in describing the creative act, the step known as illumination, everything "clicked" and fell into place. I thought that here, in essence, was the sort of dynamic model I was looking for to superimpose upon the chemically based model I had in the back of my head. This new combined theory-model immediately sparked the necessary insights for me to develop what I believe was a more adequate theory than any I had seen to explain the phenomena and resolve the inconsistencies which were apparent to me in the field of reading.

During this period, in the twilight of my consciousness I discerned first that my theory needed to be dynamic, and secondly, that the multiple regression technique needed to be extended so that a substrata analysis, not unlike

that used in chemical analyses, could be made. Furthermore, while in the air, it became very clear to me just exactly how the Wherry-Doolittle multiple correlation technique could be extended to make the necessary substrata analysis. As I was working out the finer details of this analysis the next thing I knew I again heard the words, "Please fasten your seat belts," for we were about to land in Oklahoma. The fact of the matter is that I had again fallen asleep even before we landed at St. Louis. I therefore never knew what part of my thinking took place while I was looking down on St. Louis and what part was done within the subconscious processes of my mind while I was in a sort of twilight zone between being asleep-and-awake or actually sleeping. At any rate, it was all very clear to me when I got off the plane in Oklahoma.

This brings me to my last, and perhaps most important, point. That is, obviously, I could have no quarrel with the general notion of using theory-models as a spring-board for theory building. I do have some reservations about the possibility of their being generated and used in a mechanical way. I submit that anyone turning to the theory-models approach for help in generating theory in a particular field should first thoroughly research the field itself. By this I mean that one must have a complete preparation so that he not only sees the problems, but his soul, so to speak, cries out for better resolutions of the observed facts than are given by the existing theories in the field. Then, and only then, in the incubation stage of creativity should he turn in earnest to a particular theory-model which has been prepared for him by someone else.

However, in order to know which theory-model one should turn to, one must previously have previewed a number of likely ones; and so we again are back to the chicken and egg problem. To this end, then, I feel that Dr. Maccia and her co-workers at the Center for Construction of Theory in Education are doing yeoman service. In the past few weeks I have read a dozen or more theory-models which they have constructed, and I find them interesting and provocative. While I recommend them to you as excellent reading, I would say that before you choose one you should review many, because I am convinced that when a better theory of reading is forthcoming, it will consist of the creative integration of two or more of Dr. Maccia's theory-models along with some brand new insight contributed by the theory builder himself.

REFERENCES

- Holmes, Jack A. "Factors Underlying Major Reading Disabilities at the College Level," Genetic Psychology Monographs, 1954, 49, 3-95. Published version of doctoral dissertation, 1948, Univ. of California, Berkeley.
- Lazar, M. "A Diagnostic Approach to the Reading Program," Educational Research Bulletin, 1942, 3, 1-28.
- Maccia, Elizabeth S. "The Model in Theorizing and Research," Educational Theory Center, Occasional Paper 65-180, and also delivered before the 10th Annual Convention of the International Reading Association, May 5, 1965.
- Maccia, Elizabeth S. "Educational Theory Models: A Possible Way to stretch the Bounds of Teacher Education Research," Educational Theory Center, Occasional Paper, 64-162, 1964.
- Schwartz, G. and Bishop, P. Moments of Discovery, vol. 1, New York, Basic Books, Inc., 1958.

THEORY CONSTRUCTION IN SCIENTIFIC METHOD--
A Comment On Maccia's "The Model and Theorizing In Research"

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There is a long and productive history of theorizing in the field of reading. For example, in the field of comprehension, with which I am most familiar, Professor E. L. Thorndike in 1917 published several interesting articles setting forth his theory that comprehension in reading is a reasoning process analogous to that used in solving arithmetic problems. Since that time, a good many investigators have formulated theories about the nature of comprehension in reading and conducted experimental studies to investigate these.

The fact that theory construction has played a large part in the scientific study of comprehension as well as in other aspects of the reading process is not surprising. Theory construction is an integral and important part of all scientific investigation. In fact, it is reasonable to say that the process of scientific investigation begins with the formulation of a problem to be solved or a question to be answered, usually one that arises directly or indirectly from practical experience. After formulation, the problem or question is cast into the form of a hypothesis that can be subjected to experimental tests.

Data are then gathered to permit acceptance or rejection of the hypothesis at some predetermined level of probability. It should be clear that this procedure does not establish the truth or falsity of the hypothesis; it merely determines whether the investigator accepts the hypothesis as true or false, knowing that in making such decisions he will in the long run be wrong in a pre-selected percentage of them. It is in the course of designing and conducting experiments that the ingenuity and insight of the investigator is of paramount importance. With each year, scientific workers improve their instruments and the experimental designs available for research.

On the basis of experimental data obtained in the course of testing hypotheses, the latter are rejected or accepted and woven together to form meaningful patterns. Ordinarily, the rejection of a hypothesis leads to the acceptance of an alternative to it.

Once a revised theory has been constructed, specific hypotheses are formulated and subjected to experimental testing. Thus, the process of constructing a theory, testing it, revising it in terms of new data, and constructing new hypotheses continues until experimental confirmation of expectations derived from the theory are consistently obtained.

From this description of the process of scientific investigation, we see that theory guides the formulation of experimental studies and is likewise the goal toward which they are pointed. It is the process of checking theory against experimental data that is the safeguard against the circularity and sterility characteristic of theories formulated by the classical philosophers, especially in the field of natural science. It is also clear that theory construction and data collection are interdependent. Neither one can be expected to take place alone with consistently productive results. It seems reasonable, therefore, to conclude that consistently productive theory construction is an inductive process, at least at one stage of scientific investigation.

Sometimes it is impossible to formulate theory that seems adequate to fit data that have already been gathered. It is my impression that theoretical physicists at present are unsatisfied with their theories about the nature of matter. These do not adequately fit the data about the various subatomic particles whose existence and properties have been established. To rectify this situation I don't think the physicists cast about in various other subject-matter fields (or disciplines) for inspiration. Instead, they appear to be busily engaged in improving their instruments for investigating the structure of the atom and in devising new experiments, in which they hope their improved instruments will yield data that fall into meaningful patterns and lead to the formulation of theories that can be tested and modified in successive stages.

This illustration leads me to suggest that Dr. Maccia might be willing to comment on her recommendation that one can "roam the disciplines" in search of theory useful for devising new theory. I'm sure that she can help us to see more clearly what she had in mind. At present, the idea of separating the content of theories from their form seems to me to leave a result that is analogous to Lewis Carroll's grin without a cat.

INTEGRATED-FUNCTIONAL LEARNING THEORY AND READING

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In various areas of the social and behavioral sciences, including the field of education, it is generally conceded that human behavior is largely learned. Anthropologists, sociologists, psychologists, educators, and most individuals systematically interested in complex human behavior, agree that, as one goes up the phylogenetic scale, the experience of the organism assumes more importance in contrast to the behaviors that are laid down by the biological structure of the organism. At the very least, everyone would agree that important aspects of behavior are learned.

In view of this one would have to expect the experimental science of learning in the field of psychology would be a basic science to the social and behavioral sciences. This has not been the case in the past, and the task of bringing this about can only now be begun with confidence. The newness of this opportunity is reflected in the fact that many people in the field of the psychology of learning itself, not to mention other areas of study, are still unaware of the power of this development. At any rate, the discrepancy between the relevance of and the actual application of the psychology of learning to understanding human behavior calls for some explanation, as well as suggestions for accelerating what, even on face value, should be a very productive approach. The writer's major concern has been with the development of a learning conception of human behavior, central to which has been a comprehensive theory of language. The present paper will thus make several suggestions derived from this learning conception for the understanding of and further study of reading.

It is illuminating to indicate to some extent why the principles and methods of the psychology of learning have not played a more significant role in the study of actual problems of human learning, as well as in the treatment of these problems. Two major reasons may be cited here. One is simply natural to the development of a laboratory science. In order to establish the basic principles of learning, that is, the way that the environment (experiences) affects the individual's behavior, it is the strategy of a laboratory science to artificially

simplify the events with which it deals. Thus, the laboratory investigator does not in the beginning take a sample of the complex environments seen in everyday life. He takes a very simple sample of the environment, a simple stimulus that he can readily observe and manipulate. Nor does the laboratory investigator in the beginning take a sample of complex human behavior. Rather, he deals with a simple sample that can be objectively observed. Furthermore, he cannot, when looking for the basic principles, deal with an organism that has such a complex history that it would be impossible to tell if the experimental manipulation of the simple stimulus had any systematic effect on even a simple response. So, laboratory research was at first also restricted to work with simple organisms. Since these samples in their simplicity differ a great deal from the complex events that occur in everyday life, basic study would appear to have little value in understanding the practical problems of human behavior.

However, in looking at the progress of the experimental science of learning we can now select from among the various findings and chart a course of progress. That is, it may be suggested that the first step was to discover the basic principles using simple samples of the environment: a light, a bell, or the like; simple samples of behavior: solution, a bar press, and the like; and simple samples of living organisms: rats, dogs, pigeons, and the like. Later, after discovery of the basic principles, the principles and methods could be applied to humans and more representative samples of environmental events as well as more representative samples of the behavior involved. As will be described later, this has begun to occur with great success, and with ever accelerating activity, and needs to be extended even further.

In following this interpretation, it is suggested that one of the main lines of development of the field of learning theory must be devoted to the experimental and theoretical analysis of complex human behavior, as well as to the creation of findings with which to deal with actual human problems. This has not been self-consciously seen as a major line of progress of the science by the most influential members of the science, which is another reason the principles and methods of the science of learning have not had a greater impact upon the social and behavioral sciences.

Theory in the new science of learning has been restricted primarily to gaining the precision and general character of the physical sciences in the statement of its principles -- and thus largely restricted to the findings of the basic laboratory. The prestige of this type of theory has been enhanced to the degree to which it resembled these sciences in the use of mathematics and formal logical methods. It would not be remiss to suggest that research that concerned actual human problems was accorded much less stature.

In following this path, the psychology of learning, as well as psychology in general, became very separatistic. A major part of the field was broken into warring factions that proceeded to develop separate research procedures, separate philosophies of science, and separate terminologies (theories). For a long time, the matters of greatest importance in the field involved the contests between the major approaches. This continues today. As an example, in the field of language learning there have been very distinct and very separate approaches. Individuals concerned with the learning of word meaning (see Mowrer, 1954; Osgood, 1953; and Staats, 1961) have been largely unconcerned with the principle of reinforcement (reward) as it pertains to the learning of speech (see Salzinger, 1959; Skinner, 1957; and Staats, 1963); the converse is true to a great extent. On the other hand, the large number of investigators interested in the learning of word associations and other verbal learning experiments (see Underwood and Schulz, 1960) have been largely ignored by the other two, and vice versa.

Thus, although the restriction of the psychology of learning to simple behaviors, simple situations and simple organisms was a part of the growth of the science, the separatism that has been described in the field, at least as the field pertains to human behavior, can now be seen as an unnecessary obstacle. And this obstacle has had serious disadvantages. For one thing, the separatistic approaches to learning have individually been inadequate to deal with complex human behavior. In the field of language learning, for example, the isolated approaches have been open to criticism (Chomsky, Miller, 1965; Weinreich, 1958) because each by itself is unable to handle the scope of this aspect of human behavior.

The various approaches and controversies in the field of learning have presented a picture of confusion to the scholars of other fields who were interested in

human behavior. Thus, we find that educational psychologists especially, and clinical psychologists and social psychologists, as well as sociologists and other behavioral scientists attempted to organize the field of learning to focus on the problems in their area of study. They have accepted one or the other approach to learning and found that approach inadequate, or they have presented a potpourri of the various learning theories and their findings. Such a survey is difficult to understand, even in its own context, and has little to contribute to an understanding of human behavior.

It is suggested, however, that learning in its role as a theory of human behavior has to be approached differently. The field has much to offer in this role, but not through the study of single areas of the field -- or indeed by summarizing the various experimental findings and theories in the field.

It is necessary to abstract the major empirical principles of learning from the confusion of the experimental and theoretical controversies to establish a theory of human behavior. These must be the heavyweight, important, basic, principles of learning. In many areas the major research has gone past the major principles to deal with details that cannot readily be applied to human behavior. Inclusion of all the minor findings and controversies would yield a body of principles too cumbersome to apply to more complex realms of events. In selecting the major principles it is necessary to cut across theoretical lines, and then to state the set of principles within one set of theoretical terms.

In addition to the major principles, it is necessary to outline the ways that the principles can combine to produce complex interactions of environmental events (stimuli) and behaviors (responses). Thus, although single responses may be studied in the laboratory and the principles derived corroborated with humans, we are rarely interested in single responses when we are concerned with human problems. Although the basic principles of learning may be the same from animals to man, human learning is fantastically complex. For example, we are concerned with learning many, many, S-R processes in learning to read. Furthermore, rather than single responses, human behavior may involve complex sequences of responses. And one stimulus can come in the child's experience to elicit many different responses which depend upon other conditions. Conversely, many different

stimuli may effect the occurrence of a single response. In addition, different types of responses may be intertwined - in fact, most important human behaviors are of this type. As an example, environmental stimuli may first elicit verbal responses in the individual, and these responses may in turn elicit emotional response, and the emotional responses will in turn determine what the individual actually does. Although the principles may be simple, learning occurs at each level, with each type of response, and the over-all acquisition of the behavior may be exceedingly complex.

Thus, a very important aspect of a learning theory of human behavior must involve a selection and integration of a comprehensive set of heavyweight learning principles from among the confusing mass of experimental findings and theoretical controversies that are presently available. These principles must then be elaborated to show how various combinations of stimulus and response can occur, including motor, emotional, and verbal responses.

It is necessary to take the principles and methods of this integrated learning theory and to begin to study various human behaviors and actually deal with those behaviors. Although at the beginning it was necessary to sample simple behaviors and situations, ultimately it is necessary to conduct research with human beings involved in learning complex behaviors, or behaviors that are more unique to man. The full status of the field of learning as a science will come when its principles and methods have been shown to be relevant for the consideration of various aspects of complex human behavior. A good deal of progress has already been made in this development.

The author has called this approach an integrated-functional learning theory of complex behavior (Staats, in press) to characterize the two main themes: (1) integrating learning principles and (2) extending the principles and results to functional human behaviors significant to the individual's adjustment. The author has presented the position more fully (Staats, 1964; Staats, in press; Staats and Staats, 1963). The major purpose of the present paper is to characterize the approach, especially in the functional aspect of the theory. That is, it will show how learning principles and methods can be applied to a consideration of an important, 'functional', human behavior and add to our understanding of this behavior as well as provide suggestions for the solution of some of the problems in the area of behavior. Thus, certain

aspects of reading acquisition will be considered along with the value of the learning approach for research in this area of study. The scope of the present paper prevents a full presentation of the learning principles and the stimulus-response mechanisms involved in the theory (see Staats and Staats, 1963). This paper can, however, suggest that the integrated-functional learning theory can serve as a model with which to approach problems of human behavior and in so doing describe a program of research which demonstrates this.

Motivation

A central aspect of human behavior concerns human motivation, which in a large sense involves the things that are rewarding (and punishing) for the individual, or group, with whom we are concerned. It may be said that some environmental events (stimuli) are rewarding even though the individual has not had previous experience with them. These stimuli are called primary rewards, examples of which are food, water, sexual stimulation, and warmth. A stimulus that is rewarding shows itself by the effect it has on behavior that it follows. A behavior (response) that is followed by a rewarding stimulus will be more likely to recur in the future -- or if the likelihood of recurrence is already high, presentation of the reward will maintain the strength of the behavior. The technical term for a rewarding event is reinforcer, or reinforcing stimulus.

Not all stimuli have this ability to strengthen the behavior they follow, however. Some stimuli punishments actually have the opposite effect; other stimuli have no effect in either direction. A very important principle concerns the way that a stimulus that does not have a reinforcing effect can acquire this property. This is very important because many of the most important motivational (reinforcing) stimuli for man are learned - the stimuli originally would not have had that effect.

The principle may be stated simply: A nonreinforcing stimulus will acquire reinforcement value if it is systematically paired with stimulus that is a reinforcer. Thus, a stimulus that is systematically paired with the presentation of food, water, warmth, relief from pain and irritation, and so on, should come to be a strong learned (or conditioned) reinforcer. Because of the helplessness of the human infant it immediately becomes apparent that many social stimuli will become strong learned reinforcers.

The sight, sound, touch, and other stimuli of people must come to be social reinforcers, because it is almost inevitable in raising a child that these stimuli will be paired with a variety of other positive reinforcers. It should be emphasized, however, that although it is almost universal that some social stimuli come at least in the child's early life to be positive reinforcers, the child's total experience provides ample opportunity for great divergences to develop in which stimuli will become reinforcing and to what extent. Thus, there will be great differences in the individual's system of reinforcers even in this narrow area. In addition, people, and groups of people, differ greatly in the other stimuli that will become reinforcing for them.

The system of reinforcers has great generality for understanding many different aspects of human action and interaction. The present concern, however, is with the acquisition of reading. It can be generally asserted that in this area, also, motivational variables are of primary importance. Although in the area of reading the reading program itself is important, perhaps of even greater significance is the way that children differ in their systems of reinforcement.

An example from the basic laboratory may be used to demonstrate the important effect that the individual's reinforcer system has upon what he will learn, as well as to indicate how principles may be abstracted from the laboratory.

Thus, according to the principle of conditioned reinforcement stated above, when a reinforcing stimulus is paired with a stimulus that is not reinforcing, the latter will also become a reinforcing stimulus. Let us say that we arrange a circumstance so that when a buzzer rings if a rat goes to the food bin in his cage, he will find a pellet of food. Conditions are so arranged that he only finds a piece of food there immediately after the buzzer has rung, and this is done many times. It would be expected that the buzzer, which formerly would not have this effect, would under those circumstances of training become an effective reward. It may seem strange, but there is much evidence to support the expectation, and Zimmerman (1957) has clearly demonstrated the specific effect. That is, after the buzzer had been paired with food a number of times, it alone could be used as a reward to train the animal to other behaviors. If we put a lever in the animal's cage and whenever he pressed

the lever down, the buzzer would be sounded for a short period (with no food given), we would find that the animal would learn the behavior of pressing the lever, although the buzzer would be the only reward.

Furthermore, this situation can be used to illustrate the importance of the individual's system of reinforcers in his future learning. Let us say that we have two rats of the same biology. One of them, rat A, we subject to the training in which the buzzer is presented many times, each time paired with food. The other, rat B, however, would press the lever a few times incidental to his other explorations, but would spend most of his time 'fooling around.' In this situation he would not learn the behavior, and would be a desultory worker. The difference between the animals, however, would rest solely upon the fact that for one organism stimulus had become a reinforcer, a motivational stimulus, while for the other it had not.

Children vary in learning 'ability' in just that way, and for the same reasons. Some children are raised in such a manner that some stimuli will become reinforcers for them, while for other children who lack the same experience the same stimuli will not be reinforcers. It has been widely recognized (see, for example, Rosen, 1956; Carter, 1964; Maccoby and Gibbs, 1954) that differences in the reward value of various events are effected by social class and familial training circumstances. Middle-class children, for example, find the approval of the teacher more reinforcing than do lower-class children. And, ordinarily, middle-class children will have had many more experiences in which the parents have rewarded any new skill the child has developed. Many, many times, when the child has learned to walk, to go to the toilet, to dress himself, to learn new words, to tell stories, to count, and so on, he will have been given many social reinforcers and perhaps material rewards of various kinds. Under such circumstances it would be expected by a learning analysis that for such children the products (stimuli) of acquired skills would themselves become very reinforcing. In common sense terms, for children with such fortunate backgrounds, learning (or its products) would itself become reinforcing.

It is not a difficult extension to see how this will effect learning in the classroom. The approval of the teacher and the products of one's own developing skill are the most important sources of reinforcement for 'student'

behaviors. In a manner analogous to our two animals, let us say that two children are placed in the same classroom and the two children do not differ except in their respective reinforcer systems. For one child, child A, the teacher's approval and the child's own achievements are reinforcing, for the other, child B, these stimuli are not reinforcing. Let us also say that they receive the same treatment in the class. Whenever they pay attention to materials the teacher presents and respond in the manner directed, they receive the teacher's approval, and they produce things (letters, words, pictures, and so on) which result from their new skills. Under such a circumstance, child A's attentional and working behaviors will be maintained in good strength and as a result he will continue to develop new skills. Child B's behavior, on the other hand, will not be maintained. His attentional and working behaviors will wane, and other behaviors that are reinforced by effective reinforcers, will increase in strength. Child A will be seen as interested, motivated, hard working, and bright. Ultimately, he will also measure that way on class and achievement tests. Child B will be seen as disinterested and dull, and he will ultimately measure that way after a few years of being present in school while developing skills only very slowly or not at all. This latter child is also likely to develop other behaviors that further complicate his problems (see Staats and Gutterfield, in press).

In both cases, we tend to look at the two types of behavior in terms of the personal characteristics of the child. The testing movement implies this, as do other concepts of child development. From a learning approach, however, we can derive a much more humanistic interpretation. The child's behavior in such cases is a function of what is reinforcing for him. And what is reinforcing for him is a function of his formal and informal conditioning experiences. Problems of educational training may rest upon changing the individual's reinforcing system -- or in altering the reinforcing characteristics of the classroom situation. For this task we can suggest procedures from a learning theory that will do more than diagnose school difficulties. A learning approach suggests actions to be taken to ameliorate such problems.

More specifically, in the area of reading, the topic of motivation (reinforcement) is extremely important, if not crucial. No matter how you slice it, even in perfectly phonetic languages, the acquisition of a reading behavior repertoire is an extremely difficult learning task.

When one has worked in the laboratory with animal and human learning, as well as with individual children involved in learning something as complex as reading, the fantastic complexity of the task can be seen.

Even if there were only 26 letter stimuli, each of which had to come to control a different response, it would be a very, very, difficult learning task -- quite beyond the capacity of any subhuman organism. In English, of course, the task is much more complex. Different letter stimuli in different combinations must come to control the same vocal response. And, conversely, the same letter stimulus under different circumstances must come to control different vocal responses.

It is for this reason that efforts to simplify the learning task itself are important. But, as simple as the task can be made, it will remain most complex and require long-term training. This by no means denigrates efforts to create and evaluate methods of reading training. In fact, the experimental methods to be discussed in the present paper lend themselves to this task.

However, we must consider motivational or reinforcement factors also as central to this type of learning. Because of the difficulty of the learning task and the length of time it takes to acquire the reading repertoire, we know that it will require a system of rewards that is strong. The behaviors of attending in class and responding as directed (the behaviors involved in being a good pupil) must be maintained for a long and arduous period. Without reinforcement for the child these basic behaviors will not be maintained in good strength, and then educational learning will cease.

Reading Research

It was on the basis of this type of analysis that the author began the systematic study of reinforcement variables in the context of early child learning -- especially the acquisition of reading. The first step was to create a laboratory situation to verify the applicability of the general analysis and to begin the development of methods to work with this type of behavior and with the population of subjects involved. The first study to be reported will summarize this development.

The aim of the beginning aspect of the learning analysis of reading was to construct a laboratory procedure within which reinforcement principles could be

studied objectively with young children over long periods of time, where the verbal stimuli were presented in a controlled manner. The reading stimulus materials devised for the first experimental work were selected to fulfill certain criteria. While the task chosen was to be a reading task, to produce good laboratory control the materials were selected to be as simple and as homogeneous as possible. Since words and sentences are of different lengths and difficulty, single vowels and consonant-vowel pairs were selected. In devising this program attention was also directed to a preliminary analysis of the learning to be achieved, that is, the type of stimulus discriminations which must be made and the responses which must be controlled. This analysis by no means solves the problems, but it does begin to confront them. Many investigators concerned with reading have pointed out that in the English language the same letter stimuli often must come to control different speech sounds when the letters are in different contexts. The letter a is responded variously to, as in father, fate, fast, and so on. One stimulus must thus come to elicit several responses, depending upon the context in which it occurs. This represents a complex type of learning. Although there are some general consistencies or rules according to which the stimuli of context can come to control the correct one of the several responses, there are many exceptions, and even the consistencies of context form a very complex learning task.

There have been various suggestions for overcoming such problems in the training of reading. For example, (1) English spelling may be altered and new symbols introduced; but this may make the transfer to normal English spelling quite difficult; or (2) in order to retain the actual English spelling, the system may deal with only a limited number of words, not including the many exceptions; however, this limits the generality of the learning.

The stimuli used in the present study were such that they might later be used in the study of some of these problems. The research method retains the letters used in English. However, a different identifying mark appears in conjunction with the letter for each different sound the letter must come to elicit. For example, a controls the "a" response in father, and ā controls the "a" in fate. As a result, each letter with its symbol (when necessary) controls only one response, a method consistent with a preliminary behavior analysis of the learning involved. Once the child acquires such a letter

repertoire he should be able to read any word including these letters. As the learning progresses and the context stimuli come to assume control over the correct response, the supplementary identifying stimuli could be "faded" gradually from the reading materials.

In addition, to obtain good experimental control, an apparatus was constructed in which the phonetic letter stimuli could be displayed systematically. The stimulus presentation apparatus consisted of a panel with four plastic covered windows and one of the windows centered above the other three. Pressure on any of the plastic covers activated microswitches which led to various experimental contingencies.

The verbal stimuli were presented to the child in a discrimination procedure. The top stimulus "matches" one of the three stimuli in the bottom row of windows. The child's task was to select the stimulus that matches the one in the top window. In the procedure the stimuli are presented, and the experimenter, who is not visible to the child, "names" the top stimulus. The child must repeat the name and then press the plastic cover over the top window. Then he must select the matching stimulus from among the bottom windows, press the plastic cover, and again "name" the phonetic stimulus. When this response occurs, and the match is correct, the child is automatically and immediately reinforced. If the child correctly "names" the stimulus before the experimenter does so, that is, "anticipates" the correct name, reinforcement immediately follows -- it is then not necessary to go through the matching task.

The development of the apparatus was found to be crucial in insuring that only the correct behavior is learned. For example, the apparatus insures that the attentional responses of the child are under experimental control; he must be looking at the visual verbal stimulus while emitting the response. The apparatus also insures that errors in performance are not rewarded. For example, to eliminate "guessing" the electronic control was designed so that an error required repetition of the task from the beginning. Reinforcement is thus contingent only upon a correct response.

A problem with the study of child learning over long periods of time has also been with construction of a reinforcer system that will maintain voluntary participation (see Long, Hammack, May and Campbell, 1958). Of course,

children cannot, as are animals, be deprived of food for long periods of time and kept at reduced body weight so that we may conduct research. And we cannot normally use the withdrawal of aversive stimulation as a source of reinforcement. One of the things we see on the basis of naturalistic observation, however, is that tokens, like money, become excellent reinforcers for people - even without states of deprivation of primary reinforcers. Taking this tip from everyday life, a reinforcer system following the sample principle was developed. This consisted of tokens backed up by various items which the children had previously selected - the ratio of tokens to back-up reinforcers dictated by the capacity of the tube in which the tokens are deposited.

Thus, each time a correct response is emitted, a token (a marble) is ejected from the tube into the dish in the right corner of the table in front of the child. The tokens are backed up by reinforcers of different value, the difference in value determining the number of tokens that must be accumulated before the tokens may be exchanged for the reinforcer. One class of reinforcers, the small edibles and trinkets, may be exchanged for the token on a 1:1 ratio. Small toys are exchanged for 10 tokens, larger toys (or toys of higher quality) for 35 tokens, still larger toys for 80 tokens; and the largest toys for 150 tokens. None of the toys are expensive; each token averages about one cent in value.

In the procedure, the child selects a number of toys from a large class of each value, before he commences the training program. A toy from each class is then hung in the experimental room, each above a plastic tube. The size of the plastic tube indicates the number of tokens required to obtain the reinforcer. The child may thus "work" for any of the back-up reinforcers; he may obtain an edible or a trinket by depositing the token in the funnel-shaped opening in the right upper corner; he may consecutively deposit 10 tokens in the smallest plastic tube and obtain the reinforcer above it, and do the same with the other plastic tubes; or he may work for several different back-up reinforcers at the same time.

The child can thus use his tokens to obtain four different classes of reinforcers (or trinkets or edibles) that are available to him. As soon as he obtains a toy, another that he has previously selected from the same class is placed on display so that he always has a choice among four "for which to work."

After the child had been trained to use the apparatus and to make the phonetic character discriminations, which ordinarily took two of the 20 minute training sessions, the reading procedure proper was begun. The child could press a door-bell type of button in front of him. This would bring on the next phonetic character which would appear in the top window. The experimenter (who was invisible to the child) would say the name of the character, and the child would repeat the name. This would turn on lights of the bottom windows and activate the switches connected to the plastic covers of the windows. In one of the bottom windows would be the same character as appeared in the top window, and the other two windows would contain foil characters that differed either in the diacritical mark or in the consonant or vowel letters. The child would have to select the matching stimulus in the bottom window and press its plastic cover and say the character's name again. If the selection was incorrect, a buzzer would ring and the light in the window would go out; the child would have to begin by pressing the door-bell type button again.

When the child's response was correct in all aspects, a marble reinforcer would be delivered. The mechanism would then be turned off until the child had deposited the marble in one of the possible alternatives and had put away any back-up reinforcer that he might have received. Each correct response was recorded automatically with standard cumulative recording equipment. That is, the record consisted of a pen that moved from left to right at a constant speed. Thus, time constituted the base line of the diagrams representing the child's rate of reading performance. Each time the child made a response, the pen would take a graduated step upwards. The more rapidly the child responded, the more steeply would the line slope upwards. The steepness of the slope of the line thus indicates how rapidly the child is reading. Markers were also used to indicate when the child was reinforced with a marble and when he received a back-up reinforcer, as well as when the back-up reinforcer was. These cumulative records constituted the main results of the first studies that are to be summarized.

The next step in the experimental analysis of reading acquisition was to test the combined apparatus and procedure. While each phase of developing the laboratory facility involved pilot work, it was important to determine whether the entire system would maintain the child's behavior for a long enough period of time to study

significant variables in the learning process, to see if the stimulus materials and apparatus produced control of attentional responses, to establish the feasibility of cumulative recording, to note the sensitivity of the records, and so on. The learning curves of two children run for 40 daily twenty-minute training sessions under conditions of continuous reinforcement will be presented (Sutton, *et al.*, 1964b). The first child's record showed great consistency following the preliminary training sessions. For this child the tokens appeared to immediately constitute strong and invariant reinforcers. That is, this child customarily deposited his tokens in the tubes for the larger toys, which means that several times his behavior was maintained for as many as three daily sessions with no back-up reinforcers - only tokens. The second child's working behavior in the reading training was more variable, including pauses of various intervals with consequent changes in the child's rate of reading as indicated by the varying steepness of slope of the record.

The preceding study indicated by the length and quality of the children's participation that the reinforcement system was effective. That is, although it is usually difficult to get pre-school children to attend to a task and work ardently for long periods of time, when this behavior was reinforced the behavior was well maintained. It should be remembered that voluntary participation in the training was in competition with free play since that is what the children would otherwise have been doing. Thus, the reinforcement system appeared to be very effective.

In addition, the apparatus for the presentation of the verbal stimuli appeared to function well. On the phonetic check case the child had not yet learned he received two learning trials per reinforcement. That is, he looked at the stimulus in the top window and said its name and then found the same stimulus in one of the bottom windows and said its name again, and this was followed by reinforcement. The apparatus and procedures also worked effectively in not allowing incorrect responses to be reinforced.

In addition, the recording apparatus worked effectively. The child's moment to moment responding could be recorded. The steeper slope of the curve showed when the child was reading the phonetic stimuli rapidly. Thus, the evidence for these children indicated that the various procedures] developments were functional in producing a

laboratory situation within which to study the complex human learning of a reading repertoire. Long-term studies now appeared to be possible as each of these two children emitted about 1,500 reading responses in the 40 days of training.

Although this study demonstrated the effectiveness of the use of the reinforcement system in maintaining the children's arduous learning behavior, it did not do so in an experimental fashion. That is, the reinforcement was not manipulated during the study to see the effect that its presence and absence would have on the behavior of the children. This would be necessary to more firmly show the importance of this variable in the original learning of small children.

Thus, the next step in the systematic analysis of reading was to use the laboratory facility to begin to assess variables important to the acquisition of reading. As part of this, also, there was the need to test the extent to which the facility was well enough controlled to be sensitive to the manipulation of important independent variables.

An important variable needing more systematic study concerns the schedule of reinforcement. We know from more basic studies that certain schedules of reinforcement will produce better working behaviors than others. On a practical level of dealing with children's learning, can we improve the rate of response by reinforcement-scheduling variations when complex learning is involved?

A second goal of improving the reinforcer system is also related to this. That is, it would be advisable to minimize the delivery of reinforcers to prevent satiation. Anything which postpones satiation can be considered to increase the effect of the reinforcer system, and intermittent reinforcement would reduce reinforcer expenditure.

The next study (Stasser, et al, 1964a) using additional children, was oriented towards answering these questions. Two different schedules of reinforcement were applied to each subject and rates of response under each schedule were compared. Discrimination learning was the procedure: the child was reinforced in one manner under one room-light condition, and in another manner under another room-light condition. These light-reinforcement conditions were alternated during each training session in a manner which has been referred to as a multiple schedule (Pavlov and Skinner, 1957; Orlando and Bijou, 1960).

The first child was run under continuous reinforcement for one light condition and under extinction - no reinforcement - for the other light condition. We would expect a discrimination to develop so that the reading behavior would occur under the appropriate light condition, but much less so under the other light condition. That is what occurred. Each reinforcement condition is depicted as a separate component after which the recording pen resets to the baseline. By the sixth session the discrimination begins to form and thereafter becomes even more pronounced. We clearly see how stimulus conditions (in this case the light), which are correlated with response-contingent reinforcement, can assume control over the working behaviors of the child. That is, when the light which was correlated with reinforcement, came on the child immediately began responding more rapidly. When the light condition changed, reading behavior deteriorated.

The second subject was run in a similar manner under continuous reinforcement and variable-ratio reinforcement. In the final training sessions the variable-ratio schedule had reached an intermittency of one reinforcer for an average of five responses. Higher rates of response were produced under the intermittent schedule, using, of course, fewer reinforcers. The third child's results include responding under continuous reinforcement and variable interval reinforcement where the first response the child made after an average of two minutes had passed was reinforced. As would be expected, the child's reading response rate was lower under the variable-interval condition than under continuous reinforcement.

These studies clearly show the importance of reinforcement in the context of this important type of learning. When the child is reinforced his participation is enthusiastic, interested, hard working. When reinforcement for the behavior is not forthcoming, the child's reading learning becomes desultory, disinterested, and other behaviors occur which are antithetical to learning. That is, the child when under the no-reinforcement condition would 'fool around' in various ways (for example, spin on the stool, sing, and so on). In addition, finer reinforcement principles were demonstrated. That is, it was possible to increase the vigor of the children's reading behavior with the use of partial or intermittent reinforcement schedules. Contrary to common sense notions, some intermittent schedules produce more rapid responding than does continuous reinforcement. This was evident with the children engaged in a reading task. The finding

has strong implications for practical procedures of training, since intermittent reinforcement can allow one to reduce the number of reinforcers given, and thus reduce satiation while increasing performance. These variables need further study in the context of applications to actual educational learning.

The basic principles of reinforcement-learning may be considered to have been supported in these laboratory studies. The results and the preceding analysis, however, open up further lines of study in the systematic analysis of this type of learning. The next study to be summarized (Staats, *et al.*, 1962) will indicate not only that reinforcement is important in maintaining the attentional and working behaviors of the child, but also that reinforcing these behaviors results in the actual learning of a reading repertoire. This study is a step on the way to transposing the findings in the laboratory study of reading to actual procedures for training children to read.

For this study a small group of words was arranged in a program in which words were presented singly as well as in sentences and in short paragraphs. The child was prompted to say a word as he looked at it, and was reinforced with small edibles, trinkets, or tokens backed up by small toys. Eight 40-minute training sessions were presented to the children and the number of new words the children learned to read was tested after each training session.

Three four-year-old children were introduced to the training without extrinsic reinforcement. They were given social reinforcers (*i.e.*, approval) but not the other reinforcers. This was continued until each child requested discontinuance of the activity, which was only 15 minutes for two of the children and 15 minutes into the second session for the other child. At this point reinforcement was begun and in each case the child's reading behavior was strengthened and maintained for the remainder of the training. These children acquired 16; 17; or 18 word reading vocabularies in the eight training sessions.

Three other children were given the opposite treatment. That is, they were started under the reinforcement condition and after two training sessions were switched to no-reinforcement. They learned words readily under reinforcement, but when it was "cut off," their learning behaviors extinguished. After three or four sessions of

no-reinforcement each child requested discontinuance and the condition was changed to reinforcement. In two cases the reading behavior was re-conditioned, and learning "picked up" again.

The results of this study support and extend the findings of the previously described studies. That is, when the attentional and working behaviors of the children in the reading task were reinforced these behaviors were strongly maintained. Without such reinforcement, however, the behaviors weakened and other competing behaviors that were not relevant to the task became relatively stronger. Furthermore, when the attentional and working behaviors of the children were strong, they learned new reading responses rapidly; the converse was true when the behavior was not reinforced. The observations of the children's behavior in the learning situation as well as the recorded results indicated that the minute-to-minute attentional and working behaviors of the child are basic to learning to read. When the child attends to the material and works at a high rate, he rapidly learns to read. The major variation in learning seems to be a function of these basic behaviors. Thus, it would appear that under more appropriate conditions of reinforcement, even very young children are capable of sustained work activities and can learn complex verbal skills.

The next step in applying principles from the learning model to a significant human behavior would be to conduct long-term studies in which children were actually trained to a reading repertoire. Actually, the author had begun working on the development of such procedures with his young daughter while the other studies were being conducted. The procedures established in this study have more recently been generalized to four other pre-school children, and these and other results are now being prepared for publication. It is possible to mention only some of the general results in the present paper.

The procedure and reinforcing system used were adaptations of the laboratory apparatus and procedure described in the first study presented in this paper. However, rather than being presented with the phonetic characters, the children were first trained to read the upper and lower case alphabets, and then they were trained to read single words which were later combined into words and sentences. In addition, the children were given training in being able to pronounce letters phonetically.

The children involved in this research ranged in age from two to five -year olds. A few results may be summarized for one of the children. He was a five-years and one-month-old boy at the time the study began. His Stanford-Binet IQ was 90, and he came from a working-class family with an average income. He was considered by his parents to be difficult to control and to train, and to learn more slowly than his siblings. The parents were somewhat worried about his behavior problems.

In the study it took 37 training sessions which averaged less than 15 minutes apiece, for a total of eight hours and 49 minutes, to introduce the child to the procedures and to train him to the upper-and lower-case alphabets through "t." In five hours and 49 minutes of additional training, in 22 training sessions, the child was taught 21 new words. In this period he also learned to read these words in a number of different sentences and short stories (paragraphs).

In the seven months of training in which this boy voluntarily participated before the author terminated the study, he learned a number of additional significant aspects of a reading repertoire. (It is noteworthy to point out that his parents used cessation of the training as a threat with which to control the child's behavior.) One of these, which is also a more formal study in itself, will be summarized. The study indicates that in addition to research on the motivational aspects of reading acquisition, the experimental methods and learning principles may also be used to investigate methods of training reading.

In learning to read it is necessary that single letters and other parts of words (syllables) come to control phonetic (part word) responses. In order to sound out a new word in reading new material, the child must be able to respond to the letter and syllable units with a correct sequence of vocal unit responses, the sequence then completing the word response. This type of repertoire can be trained in different ways. For example, Bloomfield (1961) has suggested that unit reading repertoires come about in a way that can be seen as an example of a type of concept formation, only more complex. Using the present procedures as examples, it would be expected that if the child were presented with the letter stimuli d, g, l, k, n, and w each in combination with each of the vowels a, e, i, o, and u - the various combinations being presented - and were trained to read such syllables, the

single stimuli involved in each combination would come to control the appropriate response unit involved in each total response. That is, the d would come to control the 'duh' vocal response, the a the 'aye' response, and so on. The present experiment only concerned the acquisition of the consonant vocal sounds (consonant concepts) under the control of the consonant letters. The learning of the consonant responses (phonemes) under the control of the consonant symbols (graphemes) was tested by teaching the child to respond to two new vowels, y and a. The new vowels were then combined with the consonants and presented to the child. These constituted novel syllables. If the consonant 'concepts' had been learned, these new syllables would be read correctly.

In contrast, another way that a phonetic reading repertoire could be developed would be to directly train the child to respond to the unit letter stimuli with unit vocal responses, rather than to use the above described concept formation presentation. That is, the child would be directly trained to give a specific vocal response to each letter. Presumably, then, when two such stimuli were presented in a new combination, the result would be the sounding out of a novel sequence of responses. In the present study the test was made by combining two of the syllables the child had already learned to read separately, da and gy, to see if the two stimuli would control the novel reading response, dacy.

At the time the phonetic training began in the present study, the child had already learned to read the vowels: a as 'aye,' e as 'ee,' i as 'eye,' u as 'oo' (actually, this required additional training since the child had previously learned to pronounce the letter as 'you'), and o as 'oh.'" In the phonetic concept training the a was first combined with the consonants to yield da, ga, la, ka, na, and va. These syllables were presented in random order. The child was prompted to make the appropriate vocal response while looking at the character and was reinforced when he had done so. These characters were presented until the child had read each of the 6 four consecutive times without error. The same process was then repeated with the other vowels in combination with the same consonants. When this was finished for all of the vowels, the total procedure was repeated twice more to the same criterion level. The child's performance on this task is shown in Table 1.

Table 1

Learning the Consonant Concepts

	Consonants with the Vowel	Number of Trials	Number of Consonant Errors
First Presentation	a	34	7
	i	108	16
	e	90	12
	u	110	15
	o	42	6
	Totals	412	56
Second Presentation	a	114	9
	i	66	4
	e	36	1
	u	36	0
	o	42	0
	Totals	294	14
Third Presentation	a	36	0
	i	36	0
	e	42	1
	u	30	0
	o	36	0
	Totals	180	1

The Table shows for each of the three presentations of the five vowels the number of trials necessary to reach the criterion as well as the number of errors made on the consonant involved. Thus, it takes 54 trials to learn the 'consonant-g' syllables on their first presentation, with 7 consonant errors occurring. The number of consonant errors increases with the next series, the 'consonant-i' series. This would be expected from what is known about retroactive inhibition. That is, presentation of the 'consonant-g' series has a negative transfer effect upon the subsequent learning. By the time the 'consonant-g' series is reached the errors begin to diminish. However, more trials are necessary to reach criterion for the 'consonant-y' series. It is possible that this increase in errors is influenced by the vowel y. That is, the child had just been trained to make a new response to this vowel (the 'oo' sound rather than the name of the letter) and this probably contributed to the complexity of the learning involved here.

In any event, by the time the 'consonant-n' series is reached, the errors have decreased markedly. But this may reflect the ease of learning the vowel involved. In the second presentation of the 'consonant-a' series, the effects of retroactive inhibition may be clearly seen. More errors are made on the consonants in the second presentation than in the first presentation. At this point it is clear that the concept learning is incomplete. Nevertheless, the number of errors continues to decrease with the presentation of the other consonant-vowel series. By the time the third presentation of the various consonant-vowel sets occurs, the child is making almost no errors on the consonants. At this point it would seem that the consonant-letter stimuli had come to control the correct vocal responses, that is, that the consonant 'concepts' had been formed.

This was tested for generality by training the child to read two new vowels, g as 'ah.' and y as 'ee.' If the concept formation had actually taken place the consonants when in combination with new vowel stimuli should still control the correct consonant responses. This possibility was tested in the following manner. The child was trained to read a new vowel, a. This was done by presenting the letter singly and prompting the child to say the correct sound, following this by reinforcement. The sound of the g was 'ah.' The card was presented in this manner until the child read it correctly 3 times. Then the new vowel was paired with each of the consonants to yield da, ga.

la, ka, na, and wa. These characters were randomly presented 5 times each for a total of 30 trials (to the same criterion of 4 consecutive errorless completions of the 6 sets of characters). This procedure was completed for the new vowel y also. In both cases the results showed almost perfect transfer of the concept consonants. There was only one error with the a series and one with the y series. The results are shown in Table 2.

Table 2

Transfer of the Consonant Concepts to New Vowels

Consonants with the Vowel	Number of Trials	Number of Consonant Errors
y	30	1
a	30	1
Totals	60	2

In addition to these aspects of the study, exploration was made of the possibility that the direct type of phonetic training that has been described can effectively produce general training that results in the child's ability to sound out words. This was done in the following manner. The child had a syllabic reading repertoire as a consequence of the training he had already undergone. In the present phase of the study two syllables were presented together to see if the child would then read them in sequence, in essence sounding out a novel bi-syllabic word.

First, all the a syllables were presented for review to the criterion of two consecutive errorless performances on all the syllables (da, ga, la, ka, na, and wa). This was then done for the syllables containing y. At this point the test for the novel behavior of reading the two together was made. This was done by presenting da on a card followed in four spaces by gy. The experimenter placed a finger under da and asked the child to read it. Then the experimenter pointed at the gy and asked the child to read it. The same thing was repeated using another card on which the two syllables were separated by only 2 spaces. On the next card the syllables were

separated by only 2 spaces; on the next by one space; and finally a card was presented on which day was typed. This card was re-presented two additional times. The same procedures were then followed with the syllable da and dy.

The results showed clearly that a new, original response may be emitted upon the basis of past learning. That is, although the reading responses had been learned separately, when the syllables da and dy were gradually combined into a two-syllable 'word', no errors were made. The child read the two syllables correctly at each step. In fact, when the day card was presented for the first time, as well as in its re-presentations, the child responded with the novel two-syllable response before the experimenter could point to the two syllables in series. The same results were obtained for the da and dy syllables.

Several other items are of interest in the results of this experiment. The training and test of the hypotheses in this study consumed 32 training sessions. The sessions were held 3 days a week and thus extended over a period of more than 6 weeks. The training sessions averaged 15.8 minutes. During this period of training the child's attentional and working behaviors were maintained in good strength by the reinforcer system. He made 1,420 reading responses for which he received the equivalent of about \$13.45 in toys.

The results indicated that a process analogous to a learning conception of a type of concept formation may take place in the acquisition of reading. A part response of a total response that was reinforced in the presence of part of a total stimulus (da) would come under the control of that part of the total stimulus (d) even when the part stimulus was combined with a new stimulus (as in dy). Thus, the control of a unit vocal response ("duh") by a unit reading stimulus (the d) occurred and would transfer to new circumstances. The study also involves an analysis of the way in which a reading repertoire may be acquired, and suggests that this complex type of discrimination learning in children may be systematically studied in the laboratory.

In addition, the manner in which original behavior can occur was also indicated by the results of the study. That is, responses separately trained to separate stimuli will occur together in a novel combination when the separate stimuli occur together. This principle has been

used by the author (Staats and Staats, 1963) to describe aspects of novel sentence generation, as well as social, scientific, and mathematical reasoning. The present results give support to the contention that behavior may be learned, yet under appropriate stimulus circumstances can occur in novel forms. Since it was found that separately learned reading units may be later combined by the child into words, the results also suggest this as a method of training a child to read. That is, it was possible to directly train the units and not have them emerge through the process of concept formation in the manner proposed by Bloomfield. Further study will be necessary to evaluate in systematic laboratory study the relative efficacy of the two methods used in the present study. The present results indicated that the whole word method of training, as in the 'concept formation' presentation, can result in the formation of reading (phonetic) units. However, it was also shown that reading units may be taught first, and then combined into words.

In general, the results with the other children similarly substantiated the principles and methods of the learning theory approach in the context of this important functional behavior. It may be concluded that the principles and methods may be applied to the study of this type of behavior in pre-school children. Although the various indications cannot be given here, it was evident that this type of study would provide us with what has not heretofore been available, namely an analysis of what reading is and how it is learned. While these studies by no means complete the research that is necessary, the outlines of the analysis of this type of behavior can now be extracted, as can implications for further research and practical applications.

I would like to mention two other studies that have been completed in this systematic study of the learning model in the context of reading. The methods of the preceding study were adapted for use with somewhat older children; in one study it was adapted to a 14-year-old culturally-deprived juvenile delinquent, and in the other to 2 educable retardates and 4 trainable retardates.

The boy who was a juvenile delinquent (the study was terminated when the boy was sent to a reform school) was given 40 hours of reading training which involved 70 training sessions extending over a period of 4-1/2 months. He received specific training on 761 words that he did not know. Later tests indicated that he had learned and

retained 431 of these words. To further evaluate the results of the training, this child was given reading achievement tests prior to the study, approximately in the middle of the study, and at the end of the study. At the beginning of the study, the subject was performing at the grade 2 level. After 45 reading training sessions, his performance on the California Reading Test showed a gain to the 3.8 grade level. By the end of the training, after 25 additional training sessions, he had advanced to the 4.3 grade level. When the child's rate of progress is plotted with his regular school training as a comparison, his rate of learning in the experimental procedures shows a considerable acceleration.

Another indication of the general effect of the reading training came from the child's performance in school, both in school achievement and deportment. The period of reading training coincided with a school term. The boy received passing grades in all subjects at the end of the semester: a C in physical education, a D in general shop, a D in English, and a D in math. It should be emphasized that these grades represent the first courses that this child has ever passed, and thus his finest academic performance. Furthermore, S began to behave better in school. The boy had always been a behavior problem in school, and this continued into the period during which he received reading training. During the first month of the training, he committed 10 misbehaviors that resulted in the receipt of demerits. These behaviors were disturbance in class (which occurred twice), disobedience in class (5 times), loitering (twice), and tardiness. In the second month he was given demerits for scuffling on the school grounds and for creating a disturbance. In the third month he was given demerits for cutting a math class and for profanity in class. However, no misbehaviors occurred in the fourth month, or in the half month after this until the conclusion of the school term.

The results of this study strongly supported the analysis of reading acquisition in terms of the learning theory, as well as the findings that had already been obtained with the younger children. Through the use of an adequate reinforcement system, this child who had always been a behavior problem in school came to learn rapidly. His attentional and working behaviors were well maintained by the reinforcement and various measures of his achievement indicated good progress. The effects seemed also to be general. The boy reported that he liked to read better and that he liked his classes more. His grades were the

been that he had ever gotten. In addition, his misbehaviors decreased. This study is now in press for journal publication (Harris and Rutterford). However, the author intends to adapt the procedures for broader study in the context of cultural deprivation and educational retardation.

The basic laboratory procedures also have been tested and further developed for use with mentally retarded children: 2 educable retardates and 4 trainable retardates, including 2 mongrelized children. The children used in the study ranged in age from 7 years and 3 months to 18 years and 8 months. The children's mental ages ranged from 1 year and 2 months to 8 years and 3 months; those IQs from 16 to 47. Each child's participation in the study was well maintained by the continuous system. However, the more retarded children tended to use these machine tokens to obtain immediate reinforcement. That is, the machine was deposited largely for the tokens and abilities, rather than for the toys which took longer to earn.

Another large difference that appeared among the children was in the quality of the children's recreational and working behaviors. In the study, additional ways of recording the time the children spent in different aspects of the task were tested. That is, the amount of time the children spent in the phonetic character discussions was computed, as was the time spent in handling the characters, as well as the time after putting the characters away until the button was pressed to bring on the next card. The latter two periods were actually a measure of the time the child spent "focusing around." One of the major reasons for poor performance was the poor quality of some of the children's work behaviors. The results suggested that further study be made of the possibility of improving these behaviors through training.

In addition, there were differences in the length of time it took to teach the children to use the apparatus. For mental 4-year-olds, only two teaching sessions are required. In the present study the educable retardates took 2 or 3 times as long. However, thereafter they performed the reading task even more rapidly than have mental 4-year-old children. In general, the more retarded the child, the greater was the length of the training required to learn to use the apparatus and to make the phonetic symbol discriminations. The more retarded child, a mongrelized retardate with a mental age of 1 year and 2 months, required special materials and a long period of training.

However, this child had no spontaneous speech reported at the beginning of testing, and it was necessary to teach the child to make an appropriate verbal response to the pictures before the testing in the reading task could begin.

One of the most important findings was that all of these children could make the discriminations involved in the task. It should be remembered that the stimuli involved were letters with functional units and that the discriminations were much more difficult than those involved with ordinary letters. The results thus suggest that the difficulty in reading retarded children is not in their ability to make the visual discriminations, although this possibility has previously been suggested (Harris and Jormer, 1963).

The study provided a number of other suggestions. The most general is that the laboratory apparatus and procedures provided a situation in which the complex learning of retarded children could be objectively studied over a long period of time. The next step will be to attempt to teach these types of children to actual expectations to find out the specific types of difficulties involved. It is likely that some of these children will have not yet to have special learning problems - the problem will be in learning circumstances they have encountered, especially in the understanding of the sources of reinforcement for self-motivated spontaneous and working behaviors. The subjects in the present study certainly appeared very normal in their general performance. The thing is quite evident throughout this project of study: when there are not adequate sources of reinforcement, attention and working behaviors are not maintained - and learning ceases.

The present series of studies thus indicates that reinforcement (motivational) variables are important to educational learning. It is also apparent that these variables have not been adequately studied and, moreover, that many problems of educational failure involve these variables. The progress made in the project in the application of an integrated-functional learning theory already yields strong suggestions for further research as well as actual applications.

Conclusions

There, however, are extensive topics and needs for a more complete presentation. The summary here does not

constitutes a full analysis of reading. Actually, only a part of the acquisition process has been described in brief. And only a part of a total learning model has been used. A more complete analysis of the complex behavior included under the term 'reading' must draw more fully from the learning model. The author is presently completing this type of analysis.

The summary of research on reading acquisition is presented as a demonstration: the importance of integrated-functional learning theory for dealing with complex human behavior, of various kinds. It is capable of producing not only theoretical understanding but also research suggestions as well as methods for actual application. It should be emphasized that the analyses stemming from the approach and from the experimental methods described herein are capable of dealing with problems of behavior - not merely diagnosing the problem of behavior, or of attributing the cause to personal data. Theories of human behavior and the problems that it based upon test data, for example, unfortunately do not provide methods of specific treatment of the behavior problem. While testing is important for the diagnostic test, tests and test theory have not been as valuable in providing means for treatment of the problem. It is for this reason, in part, that it is suggested that learning theories of behavior, and learning methods of treatment, are so much potential.

It is also suggested that one of learning principles applied to problems of human behavior in the way described has all the attributes of a clinical theory. That is, the basic principles have been systematically established in laboratory controlled experiments. These are the most general laws. The manner, which the basic principles combine or from which complex stimulus-response constellations have also been suggested. Each of these constitutes the higher-order principles (or laws or axioms) of the theory. Each time a reanalysis is made of a human behavior, it constitutes lower-order hypotheses derived from the theory. Confirmation of the hypothesis through empirical study has the effect of verifying the specific hypothesis as well as a theoretical body from which the hypothesis derived. A studies on reading that have been used could constitute both the confirmation of a specific hypothesis as well as more general support of the integrated-functional learning theory from which the hypothesis were drawn.

This suggests that the extension of learning principles to an aspect of significant human behavior, in addition to its practical value, serves to develop the learning theory of human behavior. It may be suggested that the theory already has more systematic experimental support than other approaches. Further progress in the development of such a learning theory will rest upon projects like the present one. This will have to involve various areas of behavior - the greater the number of various behaviors sampled, the more general the theory. It is suggested, however, that the theoretical body now has hypotheses and methods for the study of and extension of various aspects of human behavior.

It may also be suggested that the progress of the research on reading that has been summarized herein contains a general strategy with which to investigate various aspects of human learning. In begin such research, the investigator who is familiar with the basic principles must first analyze the behavior in which he is interested in terms of the principles. This must include an explicit statement of the observable behavior to be studied. This task is usually easier to accomplish when one deals with the behavior when it is originally being acquired; that is, in its simplest form. Thus, it would be difficult to make an explicit statement, for example, of the behaviors involved in being a mathematician. It is much easier to specify the behaviors involved in counting as well as how those behaviors are learned. (See Shanks and Shanks, 1961.) When the simple behaviors are well understood, more complex forms can be studied. Even in their simple form, however, significant human behaviors usually involve sequences of responses. And complex behaviors often involve the acquisition of the ones in which one is interested may also be involved. However, the analysis of the behavior is basic to the research that follows and cannot be done ambiguously or in a simple-minded manner. Definitely a full analysis of a significant behavior will require the type of integration of learning principles previously described. Most human behaviors involve more than one behavior principle, or more than one type of response.

In addition to systematic analysis of the behavior involved, it will be necessary to include observations of the variables involved in the acquisition of the behavior. Thus, one may have to explore the affective experiences involved, or stress, or all or other stimulus conditions affecting learning.

The next step in the extension of an integrated-learning approach often appropriately involves a "demonstrational" study. This means turning some of the main principles of the analysis in the context of the behavior of interest. For example, is reinforcement actually important in the acquisition and maintenance of the behavior involved? In any event, I have found that in this type of demonstrational study one begins to learn more about the behavior and the subject population which is involved - and one may get ideas pertinent to more systematic study of the behavior.

The next step is to make a more systematic attempt to explore the principles involved in the acquisition, maintenance, or change in the behavior under study. Additional variables may be tested at this time - reinforcement schedules, discriminative stimulus control, etc. At this stage of the long-term study of a behavior problem, one may attempt to achieve better experimental control through, perhaps, the development of improved procedures of apparatus. If the behavior under study is complex, or more significant human behaviors are, it can be expected that short-term group studies will not suffice. Procedures by which the behavior can be studied over a long period of time will have to be worked out. We must distinguish the modification of relatively simple behaviors or classes of behavior from the modification of more complex behaviors. It is challenging to us, and a momentous step, to distinguish complex interests, or shape walking versus crawling, or shape going to bed at night versus a fall. But we have to consider also the nature of these problems in learning sometimes is, as well as the task that they afford. There are important demonstrations of the relevance and applicability of learning principles to the treatment of behavior problems. However, we can't expect to bring an autistic child to high level educational achievement, or even good communication and good language behavior by working through a short-term procedure. There are many behaviors - the original acquisition of speech, the acquisition of counting, the development of complex social behaviors, work behaviors, modified mental calculation, etc. - which are acquired for us not acquired only over a period of many years. We must expect that it will take years to change or eliminate these behaviors even under good training procedures.

Nonetheless, we must begin the study of such complex human behaviors - as well as the more simple ones. But we believe that the sparse studying of a complex behavior is a

short time indicates that all behaviors will fall into place this way, or that the major problems have been solved, is unrealistic. Although it would be expected on the basis of our findings that the principles hold from rat to man, the repertoire to be acquired by man is fantastically complex. The task of establishing programs of training with which to deal with problems of complex human behavior largely lies ahead.

The learning approach appears to be tremendously productive - but there is much to do. This brings us to the final step in the extension of learning to the solution of practical problems of behavior. Based upon my research in the acquisition of reading, I would conclude that when one works over a period of years with the same problem of training behavior, first in domesticational studies, then in other systematic studies, he learns a great deal about what can be done about some of the problems involved in modifying the behavior in a benign way. With this experience he is better prepared to begin research on actual practical problems. For example, prior to actually training a child to read, I had very well worked-out schemes for the procedures to be used, which were based upon my past research.

For solving actual problems, thus, the simple knowledge of basic learning principles will not provide adequate background. Many learning theorists, occupied solely with basic problems, will confess quite frankly that they would not have the slightest notion of how to help solve human problems involving learning, e.g., how to train a child to read. On the other hand, I think the preceding steps I've outlined will provide knowledge for approaching various practical problems of behavior, in quest of general solutions.

The suggestion is, then, that it is important for investigators to become interested in the systematic and detailed study of a type of significant human behavior and continue with the study of the behavior over a long period of time, extending their progress in the extension of learning principles as far as possible towards the solution of practical problems. This suggestion, however, would obtain far less than universal support, either from many of the prominent people in the psychology of learning, or many people involved in the various applied areas dealing with human problems. Nevertheless, it is time for a change in both of these opinions.

It may be suggested that the objections by experimentalists in the field of learning to the application of learning principles and methods stem from a misconception of what science is and does. These individuals many times see the status of a science only as emerging from laboratory precision and control, and mathematical theory. This is certainly true in part. However, the paraphernalia that smack of science - for example, elaborate apparatus and the use of mathematics - may unfortunately be seen to be the heart of science. The applied areas, lacking these accoutrements of science, at least in the realm of complex human behavior, may be seen as an entirely separate type of endeavor. Such 'super-pure scientists' are thus apt to erroneously denigrate applied versus basic research.

It is true that in psychology the methods and principles of the practitioner have almost always been derived in ways other than through laboratory research. Thus, there actually has been a true separation between basic and applied work - with little overlap. But, it is suggested that this is an artificial separation, a result of the previous lack of development of relevant principles and methods in the basic science. When the relevance of learning procedures and methods has been demonstrated in an area of human behavior, it will be possible for the practitioner to use them, and as he does so, the applied and basic fields will be drawn closer together.

It should also be added and stressed that the high status of a science is reached when its methods and principles receive verification in the events of the real world. Although we revere laboratory apparatus and elaborate theoretical endeavors, we do so largely because they have produced methods and principles that make better predictions about the real world and enable us to manipulate the real world - better than the methods and principles produced by other types of study. A type of verification of a science, when its principles are relevant to events of the real world, involves the extent to which the principles of the science improve upon non-scientific conceptions. Thus, one of the avenues of support of a theory of learning is the extent to which its principles and methods can deal in an improved fashion with actual problems of human behavior. It is suggested that extension of learning principles into the area of human behavior will prove to be one of the most important avenues for producing verification and generality of the principles.

Another resistance to the extension of laboratory derived learning principles into the realm of human problems comes from the ranks of practitioners concerned with those problems. This resistance has also had its rational basis. That is, learning approaches were for a long time restricted to dealing with simple organisms, simple situations, and simple behaviors. During this period it was quite correct for the practitioner to conclude that 'brass-instrument' experimentalism had nothing to offer him in his task of dealing with complex human behavior. As a consequence, most practitioner's knowledge of learning approaches has remained limited to a few basic principles and experimental procedures. This state of affairs has persisted because the traditional course in learning theory contributes little to an understanding of human behavior. However, this is changing. There are now materials in the area of learning, as the present paper illustrates, that are relevant to practical problems of behavior. It may also be suggested that an integrated-functional learning conception of human behavior is now available (see Staats, 1964; Staats, in press; Staats and Staats, 1963) that is actually and potentially more useful to the practitioner than are the various non-experimentally derived theories of human behavior that are now more generally accepted.

Thus, at this point the practitioner who ignores a learning approach to his realm of behavior is analogous to the hunt-and-peck typist who refuses to retrain himself to the touch system. It is easier to continue hunting and pecking, but the 'waste' of the period of retraining would later be repayed many times by the increment in skill finally attained. The practitioner who converts to a learning approach will find the same rewards. He will have an advantage in his practice, and he will have an opportunity to contribute to general knowledge.

It is also suggested that the extension of learning principles and methods to the study and treatment of human behavior problems, and thus to the verification of an integrated-functional learning conception of human behavior, is occurring at an ever accelerating rate. Great advancements lie directly ahead. In this task, because the general method of the approach is based upon the manipulation of observable independent and dependent variables, the method should have advantages characteristic of other applied sciences - one of which is their "self-corrective" nature. That is, when working with observable events, it is evident when something has been

accomplished and when it has not, where principles hold and where they do not, where development is still necessary, and so forth. Since learning approaches to behavior modification are based upon a set of experimentally established principles, a development consistent with that occurring in other applied sciences can be confidently predicted.

REFERENCES

- Bloomfield, L. "Teaching Children to Read." in Bloomfield, L. and Barnhart, C. L., Let's Read: A Linguistic Approach, Detroit: Wayne State University Press, 1962.
- Carter, E. B. "Over- and Underachievement in Reading." Child Journal of Educational Research, 1964, Vol. 17, 175-183.
- Chomsky, N. "Verbal Behavior (a review of Skinner's book)," Language, 1959, vol. 35, 26-58.
- Forster, C. B., and Skinner, B. F. Schedules of Reinforcement. New York: Appleton, 1957.
- Gunn, E. J. and Zisman, B. "Visual Discrimination Learning and Intelligence in Defectives of Low Mental Age," American Journal of Mental Deficiency, 1962, 67, 15-18.
- Long, E. B., Ransack, J. F., May, F., and Campbell, R. J. "Intermittent Reinforcement of Operant Behavior in Children," Journal of Experimental Animal Behavior, Vol. 1, 113-129.
- Maccoby, E. E., and Gilks, E. E. "Methods of Child-Rearing in Two Social Classes," in W. E. Martin and C. E. Handlar (eds.), Findings in Child Development. New York: Macmillan, 1954.
- Miller, G. "Some Preliminaries in Psycholinguistics," American Psychologist, 1962, vol. 20, 15-20.
- Miller, E. E. "The Psychologist looks at Language," American Psychologist, 1958, vol. 9, 440-454.
- Orlando, B. and Weiss, E. E. "Single and Multiple Schedules of Reinforcement in Developmentally Retarded Children," Journal of Experimental Animal Behavior, 1962, vol. 1, 119-124.
- Spiegel, C. E. Method and Theory in Experimental Psychology. New York: Oxford University Press, 1953.

- Rosen, S. C. "The Achievement Syndrome: A Psychoanalytical Dimension of Social Stratification," American Sociological Review, 1956, vol. 21, 253-261.
- Selinger, E. "Experimental Manipulation of Verbal Behavior: A Review," Journal of General Psychology, 1959, Vol. 61, 61-76.
- Skinner, B. F. Verbal Behavior. New York: Appleton, 1957.
- Stress, A. W. "Verbal Habit Families, Concepts, and the Openness-Confusingness of Word Classes," Psychological Review, 1961, vol. 68, 199-206.
- Stress, A. W. "Comments on Professor Russell's Paper," In Verbal Behavior and Learning, C. W. Cofer and R. S. Mowrer, eds. New York: McGraw-Hill, 1961.
- Stress, A. W. "An Integrated-Functional Learning Approach to Complex Behavior," Paper presented as part of the first annual Carver Symposium of Technology Symposium on Engineering. New York: John Wiley, in press.
- Stress, A. W. (ed.) Human Learning. New York: Holt, Rinehart and Winston, 1966.
- Stress, A. W. and Russellfield, W. "Treatment of Non-cooling in a Culturally Devised Acoustic Delinquency: An Application of Learning Principles," Child Development, in press.
- Stress, A. W., Finley, J. R., Minko, E. A., and Wolf, M. "Reinforcement Variables in the Control of Vocal Raising Responses," Journal of Experimental and Social Psychology, vol. 7, 139-149.
- Stress, A. W., Minko, E. A., Finley, J. R., Wolf, M., and Minko, E. A. "A Reinforcement System and Experimental Procedures for the Laboratory Study of Raising Acquisition," Child Development, 1966, vol. 37, 209-219.
- Stress, A. W., and Stress, C. E. Complex Human Behavior. New York: Holt, Rinehart and Winston, 1961.

Steele, A. W., Storer, E. E., Schuck, E. E., and Wolf, W.
"The Contribution of Tactile Stimulation to the Development
of Intelligence," Journal of Experimental and Social Psychology,
1962, 2, 25-43.

Underwood, E. J. and Torgue, E. W. Memory Systems and
Tactile Learning. Chicago: E. P. Dutton, 1968.

Wolfe, H. "Routes Through Symbolic Space," Psychol.
vol. 56, 100-108.

Zimmerman, E. W. "Dialectic Secondary Reinforcement:
Method and Theory," Psychological Review, 1962,
Vol. 69, 275-285.

A THEORY OF HUMAN LEARNING FOR TEACHING READING:
A DISCUSSION OF PROFESSOR ARTHUR STANES'S
"INTEGRATED FUNCTIONAL LEARNING THEORY FOR READING"

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The integrated functional learning theory for reading, proposed by Professor Stanes as a model for explaining the acquisition of accurate responses to printed stimuli, carefully controls (a) frequency of input stimuli, (b) reinforcement of correct verbal responses by means of tokens for purchasing food or toys, and (c) attention to relevant stimuli in the learning situation. With an instructional device based upon his theory, Stanes has demonstrated (a) that children, even preschoolers, remedial readers, and delinquents, can be trained to respond accurately to printed words, at least in the initial stages of learning to read, and (b) that experimental manipulation of certain parameters of the instructional model, particularly the reinforcement schedule, results in changes in response behavior that could have been predicted from research on the effects of inter-schedule reinforcement (Humphreys, 1955). The technical context and quantification achieved through the utilization of this instructional model is representative from an experimental viewpoint because in it through such context and quantification clear precise relationships can be determined. However, there are some explanatory and heuristic limitations to Stanes's proposed learning theory and some heuristic inadequacies to his model for teaching reading that will be discussed in this paper. Throughout this paper suggestions will be made for a theory of human learning for teaching reading.

Instead of the claimed integration of learning theory principles, Stanes's theory fits neatly into the stimulus-response group of learning theories (Hilgard, 1958), as formulated prior to the development of the educational hypothesis (Ogden, 1953), which provides a bridge between stimulus-response and cognitive theories of learning. Stanes's learning theory seems to be derived entirely from Skinner's reinforcement of selected response theory of learning, but as really presented, Stanes's theory resembles Thorndike's S-R theory of learning.

Some years ago, Thorndike explained that since learning to read depends upon acquisition of correct responses to words, his S-R theory could be used as a model for reading instruction. Because of the rationale of S-R theory, Thorndike reasoned that the most frequently occurring words in reading should be taught first because these words would result in a high degree of natural reinforcement. This curriculum strategy led Thorndike to construct his Teacher's Word Book (Thorndike, 1921, 1931; Thorndike and Lorge, 1944), which became the word frequency source book for all present day basal readers.

Although reinforcement may be necessary for learning, at least in the judgment of some learning theorists (Hilgard, 1956), the nature of reinforcement for human learning can be different from that which seems to be necessary for infrahumans. Reinforcement of primary drives plays a prominent role in learning experiments on infrahumans partly because such reinforcement serves (a) as a necessary communication system between the experimenter and the infrahuman subject and (b) as a goal emphasize in the learning situation. Caution, however, has to be exercised lest this external reinforcement itself becomes the goal. If such a substitution occurs, then the absence of the reinforcing stimulus would result in inattention or the loss of goal-oriented behavior. Such behavior, observed as "fooling around," apparently did occur when Professor Staats experimentally omitted reinforcing stimuli in the midst of an instructional sequence.

Use of such external reinforcement for communication with human subjects is unnecessary, for even three-year old children can converse directly with the experimenter or the teacher. In other words, verbal feedback can be used to give human subjects knowledge of correctness of response. Furthermore, instead of primary motivation, higher order motives such as curiosity can be relied upon for motivating the learner, particularly if the learner's primary needs have been satisfied (Maslow, 1943). The use of curiosity as a motivational force was well stated by Harlow (1953) when he explained that children as well as monkeys are curious creatures who can enjoy achievement for its own sake; witness the monkey who continues to solve problems even though his cheek pouches are full of food so that he can "reward" himself for both correct and incorrect responses. Even under such conditions, monkeys can increase their ability to learn how to learn (Harlow, 1949). Certainly higher order primates, like children, can also learn without extrinsic reinforcement.

Therefore, instead of relying upon a behavior repertoire of external reinforcements alone for communication and gratification of primary drives, the experimenter or the teacher, following certain principles of field theories of learning (Hilgard, 1948) can arouse children's curiosity about the printed stimuli, verbally arouse children to reading goals, and show children means of reaching the goal of deriving meaning from the printed page.

Arousal of children's curiosity about printed stimuli is relatively easy in the initial stages of reading instruction because when children first come to school they expect to, and are eager to, learn to decode these stimuli so that they too can participate more fully in the printed aspects of their culture (Stammler and Young, 1950). Moreover, the experimenter or the teacher could strive to have children learn to anticipate and confirm their own responses through a stimulus-response chaining determined by the accumulated sense of the passage. Also, children can be taught to actively engage in reading by formulating, and then reading to answer, their own questions (D. W. Gilbert, 1954) and thus read to attain the goal of satisfying their own curiosity. In fact, more children want to learn to read, are pleased when they can decode printed stimuli, and increasingly seek out this activity for its own sake (Olson and Hughes, 1964), particularly as they become cumulatively more successful in obtaining meaning from the printed page. Hence, an individual's curiosity can be utilized to arouse, sustain, and direct the individual's energy, provided the individual has had adequate instructional guidance so that he can be reasonably successful in solving reading problems, as in recognizing non-sight words or getting the intended meaning from a story.

Staats's instructional model does provide very well for such guidance through careful control of the sequence and frequency of printed stimuli to which the individual is to respond. Implicit in his curriculum is the narrow definition of reading that correct oral responses to printed words is reading, but even if Staats's model were used to teach children to read according to the broadest definition of reading, the question that would still arise is whether his theory would explain the acquisition of reading behavior and would stimulate research that would enhance our understanding of how individuals do learn to read. This question would arise because no attempt has been made in his theory to explain how the learner can acquire, organize, store, reorganize and mobilize word

recognition, word meaning, and reasoning-in-context, activities for responding to the printed page (Stigoe, 1968, 1969). Essentially, Reader's Job must take into consideration the cognitive capabilities of the learner for acquiring, processing, organizing, and utilizing a response repertoire for reading.

One of the facts that confounds the situation in developing new children have to deal in the enormous variety of all phoneme-grapheme relationships in the English language. For example, "eye, sea, le, l, ve, ve, and right" have different graphemes for the same phoneme, "l." The learner must acquire not only a repertoire of responses to each printed stimuli, but if he is not to suffer a cognitive overload in learning to read, he must somehow (a) reduce the variety of stimuli and (b) develop fluidity in shifting his mental organization from one word recognition approach to another (Galan, 1962; Rumelt and Leiff, 1962). Because an individual does have essentially manipulable cognition and linguistic capabilities, it is possible for him to achieve the necessary data reduction by learning to read by building up a repertoire of word recognition and word meaning concepts that can be appropriately utilized for acquiring speed and power in reading (Stigoe, 1968, 1969). To the extent that the individual can and does learn to group and mentally categorize such stimuli as those that have (a) the same sound, but different visual characteristics, as in "eye, l, sea," and (b) the same visual characteristics but different sounds, as in "cough" and "though," he can reduce the complexity of his storage and response system to printed English. If an individual also demands meaning as he reads, he can employ a powerful tool of accumulated word meanings or contexts clues for judging whether he has made an inappropriate response and therefore should switch to a more appropriate one. To facilitate the development of this conceptual storage and response system that could be flexibly utilized for reading, the curriculum could be organized according to common auditory, visual, and perhaps kinesthetic word or word-part groupings. Thus, instead of a word frequency curriculum which complicates the learning task because of the high degree of perceptual similarity in words that occur frequently in the printed language, a curriculum designed for whatever structure is inherent in printed English would not only simplify the perceptual discrimination task, but would also stress cumulative transfer (Bruner, 1967) and enable individuals to learn how to learn to read.

Although individuals can apparently do better on word in a word frequency learning curriculum, which shows a positive word association, they could learn to read perhaps better and at a stronger rate if instruction were organized not just in such higher mental processes as abstraction and generalization (Case, 1985). Even when reading instruction strategies rely on rote-learned, some individuals may invent their own learning strategies so that they can achieve higher mental processes, perhaps because such mental processes, which result in the formation of word recognition-based meaning concepts, are probably necessary in order to learn the memory load that word counts in individualized to develop a separate response for each variation word. His learning strategy may have been improved by some other children who, as early as the second grade, could recognize words in which they had not been instructionally exposed (Case, 1982). Perhaps these children, in their 6, had mentally sorted out, abstracted, and formed word recognition concepts from appropriate memory images of instructionally-determined single words. Thus, in response to the demands of the curriculum, these children continue gradually learned to abstract their stored word recognition concepts in the necessary sequence and with sufficient variability so that they were subsequently able to accurately recognize printed words that were not in the sight word repertoire. The curriculum, however, can be argued to develop such word concepts, as can those for spelling with successful transfer results (Case, 1985). Some of the similarities between spelling and word recognition (Spencer, 1986; Blevins, 1988), the probability that a similar organization in reading instruction would also result in greater transfer to word recognition. Certainly, prediction could also have to be made: teach children appropriate conceptual word (Leah, 1987) or limits to their generalizations (Dinger, 198).

Of course, S-R theory can explain how individuals can learn to discriminate, abstract, and generalize; but S-R theory cannot predict the formation of conceptual systems. However, if the cognitive capabilities of the human learner were added so that a theory would be an explicitly formulated Stimulus-Organism-Response model, then Hypotheses could be derived and tested to determine the conditions under which the cognitive capabilities of the learner can be developed into an adequate system for handling the mass of detailed information that is necessary for responding accurately and meaningfully to printed words. Hypotheses on the functions of additional systems are

already being tested. For example, Marshall (1960) has reported that individuals who had acquired specific abilities through preliminary experimental manipulation could organize and combine more information from their reading than a matched group of individuals who had not received processing on these specific abilities.

Summary

The "Integrated Learning Theory for Reading" proposed by Professor Thorne is not integrated with Scott nor with Stahl theories of learning. Because Thorne's theory does not explicitly take into account such human attributes as conceptual and linguistic abilities, it has limited explanatory and heuristic value. An instructional model, based upon a theory which encompasses all the abilities, could utilize a more humanistic approach to teaching reading. In this approach, printed materials would be organized to facilitate the development of conceptual systems for responding to printed words. This conceptualization process would consequently reduce "cognitive noise" (Thorne, Goodson, and Hickey, 1977) that would otherwise come from seeing as from a separate response for each non-identical printed word stimulus. Moreover, in accordance with Stahl theory concepts of learning, an individual could be taught to demand meaning from reading so that he could learn to combine the ambiguity of the response as he reads. If the individual were also taught to formulate his own questions as he reads, he could read for the hermeneutic goal of satisfying his own curiosity. Perhaps individuals who have learned to remove their curiosity by formulating their own questions and reading for the usual purposes of finding answers to those questions are the ones who probably choose to read during their leisure time partly because of the consequent self-satisfaction obtained while reading.

REFERENCES

- Arnold, David E. "The Use of Attention Organization in the Learning and Retention of Meaningful Verbal Material," Journal of Educational Psychology, 1968, vol. 60, 267-272.
- Brown, Jerome S., Goodnow, Josephine E., and Austin, George A. A Study of Writing. New York: John Wiley, 1967.
- Brown, Jerome. The Elements of Education. New York: Vintage Books, 1965.
- Care, Ross. A Study of Critical Reading Comprehension in the Intermediate Grades. Teachers College Contributions to Education, 1963, No. 813.
- Care, Arthur E. Comprehension and Reading in Writing. New York: Bureau of Publications, Teachers College, Columbia University, 1963.
- Care, Arthur E. What Research Says to the Teacher, No. 11, Reading, Writing. Washington, D. C.: National Education Association, 1965.
- Care, Arthur E. "The Word Recognition Abilities and the Reading Structures of Second and Third Grade Children," Reading Teacher, 1965, vol. 17, 41-45.
- Clifton, Boris H. Speed and Speed in Writing. Englewood Cliffs, New Jersey: Prentice-Hall, 1966.
- Deane, Anne. "The Formation of Learning Sets," Psychological Review, 1968, Vol. 75, 15-40.
- Deane, Anne. "Hiss, Harkness, Hiss, and Harkness," Psychological Review, 1965, vol. 72, 25-35.
- Hilgard, Ernest. Theories of Learning. New York: Appleton-Century-Crofts, 1968.
- Hilgard, Ernest. Theories of Learning (Second Edition). New York: Appleton-Century-Crofts, 1968.
- Humphrey, L. E. "The Effect of Random Presentation of Reinforcement on the Acquisition and Retention of Conditioned Pavlovian Responses," Journal of

Experimental Psychology, 1958, vol. 25,
186-191.

Hebb, D. O. "A Theory of Human Motivation,"
Psychological Review, 1961, vol. 68, 175-186.

Hess, W. C., and Hughes, E. O. "Concepts of
Anxiety: Their Significance to Teachers,"
Childhood Education, 1960, vol. 35, 25-32.

Hopwood, Gordon S. Anxiety and Worry in Speech-
motor Functioning. New York: Alfred Knopf
Press, 1955.

Kennell, E. O. "Speaking Anxiety in Relation to
Reading and Vocabulary Achievement,"
Elementary English Review, 1960, vol. 25,
15-17.

Kennell, E. O., and Goff, F. J. "Personal Factors
Influencing Reception in Reading," Education,
1955, vol. 75, 465-467.

Linger, Mary. Conceptual Anxiety in the Suburban
Junior High in Reading. Unpublished M. A.
Thesis, University of California, 1960.

Linger, Mary. "Suburban Junior High in Reading:
Conceptual Anxiety in Reading," in
J. R. Fliegel (ed.), Challenges and Responses
in Reading: Proceedings of the Fourth Annual
Conference of the International Reading Associa-
tion, 1962, vol. 7, 105-112.

Miller, E. O. "Developmental Stages of Read and
Non-Readers," Journal of Educational Research,
1960, vol. 54, 185-190.

Monahan, Olive Marie, and Thompson, Norman. "The
Basis of Reading: From Read to Non-read to
Anxiety," Child Development, 1959, vol. 30,
181-188.

Warriner, E. L. The Teacher's Read Book. New
York: Bureau of Publications, Teachers
College, Columbia University, 1965.

Warriner, E. L. The Teacher's Read Book of 19,000
Words. New York: Bureau of Publications,

Teachers College, Columbia University, 1911.

Thorndike, E. L., and Lorge, I. The Teacher's Word Book of 10,000 Words. New York: Bureau of Publications, Teachers College, Columbia University, 1944.

Zaxlow, R. W. A Study of Concept Formation in Brain Damaged Adults, Mental Defectives and Normals of Different Age Levels. Unpublished Ph.D. Dissertation, University of California, Berkeley, 1937.

A DISCUSSION OF STANES' "INTEGRATED-FUNCTIONAL
LEARNING THEORY IN READING"

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In Dr. Stanes' paper we see a direct application of B. F. Skinner's operant conditioning principles. These principles are based largely on work curves generated by reinforcing or punishing hungry rats and pigeons for doing specific tasks. There is certainly nothing wrong with generalizing and testing principles of animal behavior on human behavior. Skinner, Pavlov, and others have contributed some valuable insights which we can apply here in the reading situation. However, Skinner, and, as we see in this paper, Stanes, are laboring under the extreme difficulty of men who have found but a piece of the truth and proceed as though they have found almost the whole truth or a major portion of it.

Stanes indeed makes several precautionary statements about the need for more work and further development of learning principles, but one gets the general feeling from the very way in which he uses such terms as "the learning principles" that really a good deal of the whole field of learning has now been set down.

Stanes gives himself clearly on the side of the angels. He tells us that he is using "the methods of science" and then he proceeds to teach nothing but such currently popular subjects as how one thinks, the inner voice dialogue, and a few scattered notions. How can one go along with not only science on one side but also popularizations like this?

One wonders how far such as these will take us in the increasing inevitable paper and lecture to put in in perspective. The acquisition course mentioned in Pavlov and Skinner's book were developed with purposes that have been applied to human beings. It is certainly true sometimes like Stanes can take and apply them to the reading situation. However, the problem of these operant conditioning people is that science remains an linguistic exercise. He says that Pavlovian theory says (page 17):

"For one thing is quite evident throughout this project of study, often there are not adequate sources of reinforcement, attention and working behavior are not maintained--and learning often ceases."

If the sparse reinforcement people could get their heads a few inches above the sea level on the attention scale they might notice that in America some 5 million children enter third grade each year and the overwhelming majority of them leave in such a state the teacher giving them nothing but hope.

Skinner takes a number of references to an "integrated functional learning theory of complex behavior" which apparently will be discussed in greater detail in the forthcoming book. In attempting an integrated theory he departs from Skinner, who at least verbally stated a clear view of "theory." Skinner is also willing to discuss such things as emotion as a motivating variable between the environmental stimuli and the behavior. A good theorist would prefer to discuss only the stimuli and the behavior. Hence there is hope that there is forthcoming theory will be broader and more encompassing of the total reading act than we see in the experiment he has described. His experiments are very close to a conditioned reflexive model but the theory and the somewhat broader, as this confused article is apt to be, encompasses the complex phenomena we call "reading."

In conclusion I would like to say that I am delighted that there are scientific experiments being conducted in reading along these lines and I am also pleased, though not quite delighted, that there is something going on about it. However, this paper and the experiments described in it seem to me to be very closely tied to that school of rigid behaviorism known as sparse conditioning. The answer to which "learning integrated" are discussed seems to me to be a big answer.

the following assumptions:

1. that functions and systems which can be represented by systems,
2. that a general unification among the various systems is both desirable and achievable, and
3. that there exist general systems (and "strictly" only in any sense of a concrete type, independent of the particular properties of the systems or the elements involved" (Bertalanffy, 1955, p. 118).

General Open Systems Theory has been described by Ashby (1956, p. 11) as encompassing all a system involving the interaction of systems that are complex. Ashby notes that for the past few hundred years science has been concerned primarily in dealing in simple, *i.e.*, in idealizing the world out of which complex structures are made. These idealizations included the simple machine, Newton's, the various continuous models, Roper, the communication model for photographing an organism. The role has in instruments and study are variables in a time.

Bertalanffy (1955, p. 11) indicates that one of the main problems of General Systems Theory is to deal with organized complexity. Organized complexity can be defined as a special systems theory that a larger complexity involving organized complexity which has "systems" in general in order to understand the characteristics of such organized complexity.

Bertalanffy defines a system as "total of relations existing in interaction" (1955, p. 11).

David Hilbert gives a comprehensive definition of a system:

... are comparatively abstract approaches of dynamic elements that are in some way interconnected and interdependent and that continue to operate together according to certain laws and in such a way as to produce a characteristic or total effect. A system, in other words, is something that is concerned with some kind of activity and processes a kind of integration

and active, and a particular system can be recognized as distinct from other systems in effect, however, it has to demonstrate relations. Systems are to complex, they are to made up of interdependent sub-systems, each of which, though less autonomous than the entire aggregate is, nevertheless, itself distinguishable in operation (1962, p. 100).

Increasingly from these difficulties defining a system, even though it is obvious that a particular social system is part of a larger system such as a nation, which is true in case of the Hindu dev, which is subsumed in the universe. The definition of a system is different and is highly dependent on a given definition of a unit of analysis.

The concept of system, then, implies a goal or purpose, and to further theoretical and empirical social science components in space

A sociological system is an organization whose components are inter-related, working together to achieve a common goal and each are related to a common external world (Bryman, 1982, pp. 12-13).

Systems are also along the dimensions: (i) the level of observation (individual, intermediate, or societal), and (ii) the type of description (descriptive (function, structure, state, etc.) (Bryman, 1982, p. 12). The two-dimensional approach for representing social institutions and human organization in the Organizational Space (Bryman, 1982).

From an analysis of systems and particularly viewed in a number of domains including biology, chemistry, and physics, sociologists (1962, 1969 p. 1, 1982) identify that an abstract social institution of an Organizational Space (Bryman, 1982), serves (1982) as criteria:

1. Social Systems exchange energy and information with their environment through open and closed channels.
2. Social Systems tend to be characterized by steady states or states of dynamic equilibrium - a condition never being disturbed by the components of the system. An unstable system is that of a society.

When these signals in a flame go awry, the gases rapidly in the instant time and sometimes this can be long in the environment of the flame control system.

5. **Spur Variable selection** (regarding inclusion of the variable in model) is about state after being selected. A model with variable x than in model, but the model partly regains the correct characteristics and the inclusion of the variable has been correct.
6. **Spur Variable selection** (regarding : a fixed state and is reached that difference conditions after different state. Some situations the concept of selection in the case of the fixed state of the same case, one of them is otherwise, the other not one.

While all these views are based upon different assumptions as to the nature and scope of development, there is a wide consensus among these views that development is a process of continuous change in development. This view seems to lead to the idea that the development stage is a process of continuous change, rather than a series of individual stages. The process stage is a continuous stage which is, in essence, more or less continuous. It is a process stage which is not a series of individual stages, but a continuous stage of development (Lund, p. 195).

5. Some scholars identify a primary function of the system operating as a control system which is to act consistently for the achievement of a social goal. A change of goal operates as a function of the operation of the system. "The social, moral, legal, religious or other, the change in social structure operating as an effect" (Bakhtin, 1988, p. 199).

7. Open Systems display progressive segregation - a process wherein systems divide into a hierarchical order of subordinate systems. It has been assumed that the process of segregation is related to negative entropy wherein the organism progresses to higher levels of order and differentiation. Disorganization (positive entropy) and organization (negative entropy) operate in a living organism during the entire course of life.

In the early stages of life, organization outruns de-organization, so that the organism becomes more and more differentiated or, in other words, grows. With adulthood, life continues, but growth slows to a stop. With old age de-organization outruns organization, and with death organization terminates and de-organization, resulting from the free play of entropy, has full reign (Bray and White, 1954, p. 75).

8. Open Systems also display progressive integration. Higher order systems are continually being formed from the organization of smaller systems into functional hierarchies united to cope with problems of greater complexity than can be handled by any of the subordinate systems alone. This is a function of negative entropy.

Concurrent and independent of Bertalanffy² (1945: 1949 (trans. to English, 1952), 1950a & b, 1951, 1955, 1956, 1962a & b) and other open system theorists who have published in The Society for the Advancement of General Systems Theory since 1956, and the Journal of Behavioral Science also founded in 1956, Holmes (1948, 1953, 1954, 1960, 1961a & b, 1963a & b, 1964a) and Holmes and Singer (1961, 1964, 1965) developed the Substrata-Factor Theory of Reading.

The major hypothesis of the analysis to be described in this paper is that the Substrata-Factor Theory of Reading and Open Systems Theory are isomorphic to each other, i.e., are structurally similar.

Brodbeck points out that isomorphism requires two conditions:

1. There must be a one-to-one correspondence between the elements of the model and the

elements of the thing for which it is a model. For every chimney stack, there is a miniature chimney. Every window has its replica and vice versa.

2. Certain relations are preserved. For instance, if a door is to the left of a window in the original, their replicas are similarly situated; the model is constructed to scale. The model may or may not "work" on the same principle as the original. If it does, the isomorphism is complete. If for instance, a model of a steam engine is also steam propelled, then the isomorphism is complete (Brodbeck, 1959, p. 374).

The breadth of the Substrata-Factor Theory is indicated by Holmes in the following summary which defines reading in terms of his theory:

In essence, the Substrata-Factor Theory holds that normally reading is an audio-visual verbal processing skill of symbolic reasoning, sustained by the interfacilitation of an intricate hierarchy of substrata factors that have been mobilized as a psychological working system and pressed into service in accordance with the purpose of the reader (1960, p. 115).

Significance of Analysis

The significance of the following analysis rests in its attempt to show that the essential form of the postulates of the Substrata-Factor Theory are identical with the generalized form of the fundamental postulates that have been discovered to hold for modern theories in other sciences. If this can be done, it will show that the postulates of the Substrata-Factor Theory which were formulated to explain the content of a specific discipline, reading, without regard to form, nevertheless, fit the formal criteria of the General Open Systems Models as abstracted from other sciences. What would this prove? Most importantly, it would show that the formal aspects of the Substrata-Factor Theory were not only consistent with similar Open Systems theories in other sciences, but

also that it was internally consistent. The presentation that follows is an attempt to show how the Substrata-Factor Theory parallels General Open Systems Theory.

In this paper, each of the General Open Systems Theory postulates is stated. After each general postulate a discussion relates the Substrata-Factor Theory in that area to the General Open Systems Theory.

General Open Systems Theory Postulate I: Exchange of energy, information, or matter with the environment through input and output channels. Interaction between the individual and the environment implies that the total variance of any response can be accounted for only in part by individual differences. It depends also on the stimulus characteristics of the environment and the interaction between the individual and his milieu.

The total range of "outside" and "inside" variables has an impact on the output of the individual's achievement. S. B. Sells (1963, pp. 9-13) has outlined some two hundred manageable variables that can be empirically measured. Sells' effort is a first step toward the development of taxonomic dimensions to account for the total stimulus situation.

The five major headings around which these two hundred variables are grouped include natural aspects of the environment; man-made aspects of the environment; description of task-problem, situation and setting; external reference characteristics of the individual; and individuals performing in relation to others.

The Substrata-Factor Theory predicts that a child's achievement hierarchy, which would include many variables in each of the above five major headings, will undergo a gradient shift or orderly change as he progresses through school. As the individual increases his proficiency in newly learned subskills, the content and structural organization of the substrata factors in the hierarchy which underlie his developing ability to achieve will also change.

General Open Systems Theory Postulate II: Maintenance of steady states. The concept of a steady state was probably first stated by Mareau de Maupertuis (1698-1759) in his Essai de Cosmologie (1750) in which he described the principle of least action. In biological terms Claude Bernard (1865) expressed Maupertuis' principle as the maintenance of the internal environment. Fechner (1873),

in a practically unknown monograph, describes his idea of the steady state as follows:

All development progresses in the direction of an always more complete utilization of energy for stationary systems - maximum stability, therefore, always means maximum utilization of energy (quoted in Menninger, Mayman, & Pruyser, 1963, p. 82).

Cannon conceived of homeostasis, wherein a physio-chemical constancy is maintained, such as the automatic regulation of body temperature, the pH level of the blood, and the maintenance of osmotic pressure.

In the field of reading, the Substrata-Factor Theory postulates a working system of subabilities which are directed toward the solution of a problem.

. . . . The problem organizes the abilities, as the abilities determine what may be organized. That is, the particular kind of problem requires a certain organization of abilities, as the individual possession of certain abilities limits what he may organize (Holmes, 1953, Ch. 32, pp. 1-2).

Neurologically, a working system is conceived of by Holmes (1960, p. 117) as a nerve-net pattern in the brain that functionally links together the various subsystems that have been mobilized in a workable communications supersystem. A first approximation of how this working system might be determined is at present statistically derived by a Wherry-Doolittle-Holmes Substrata Analysis.

On the basis of Holmes' extension of the steady-state principle to reading, the Substrata-Factor Theory predicts that working systems would vary with the problem, the purpose, and the stage of psychoeducational neurological development of the individual.

General Open Systems Theory Postulate III: Self-regulating tendency--reestablish a steady state after being disturbed.

. . . . The very counteractivity which corrects the undesirable deviation often proceeds in an oscillating fashion. Restoration of the original state of equilibrium

is not a very smooth process, but consists of a series of pulls and pushes, like the swings of a pendulum, which gradually approximates the center-of-gravity position. The corrective activity may overdo or underdo the job it is called to do; there may be an overshooting or undershooting of the mark while the corrective process is going on (Menninger, Mayman, & Pruyser, 1963, pp. 87-88).

In terms of reading, the deviation of a working system from its steady state may be manifest in the return sweep, number, and pattern of fixations, regressions, and the duration of fixation. For instance, regressions have been studied most intensively by Bayle (1942), who noted that causes of regressions may be found in the type of material and the difficulties the reader experiences in deriving meaning. Six interpretation difficulties which affect the eye-movement patterns were identified by Bayle as word order; word grouping; misleading juxtaposition of certain words; lack of punctuation to make the meaning clear; shifts in the meaning of words; and the necessity for concentrating on key words or key elements in sentence units.

The Substrata-Factor Theory holds that when the working system is inappropriate for the reader's purpose (specific word attack in an otherwise easy passage), the steady state will be disturbed, and the working system will make internal adjustments in an effort to solve the problem. Upon clarification, the original working system will be restored.

Several interesting questions are raised by Menninger, Mayman, and Pruyser (1963) about the concept of self-regulation and return to the steady state.

Is there a complete return to the status quo ante?

Is the process of disequilibration to equilibration a circular one?

Are the mechanics of control the same at every level?

Does it equally apply to parts and wholes, to systems, subsystems, and supersystems?

Is there growth of self-regulating action and decline of it?

Most of the answers to these questions would involve carefully executed microscopic and macroscopic studies, but the Substrata-Factor Theory would predict, as far as reading is concerned, a qualified negative answer to the first four.

General Open Systems Theory Postulate IV: Equifinality. Bertalanffy has pointed out that equifinality in Open System Models is another of the characteristics which distinguish them from closed systems:

In closed systems the final state is unequivocally determined by the initial conditions: for example, the motion of a planetary system where the position of the planets at a time t are unequivocally determined by their position at a time t_0 . Or in a chemical equilibrium, the final concentrations of the reactants naturally depend on the initial concentrations. If either the initial conditions or the process is altered, the final state will also be changed. This is not so in open systems. Here the same final state may be reached from different initial conditions and in different ways. This is what is called equifinality, and it has significant meaning for the phenomena of biological regulation The sea urchin can develop from a complete ovum, from each half of a divided ovum, or from a fusion product of two whole ova. The same applies to embryos of many other species, including man, where identical twins are the product of the splitting of one ovum (1955, p. 77).

The Substrata-Factor Theory states that different individuals (or the same individual at different times) may perform the same task to an equal degree of success by drawing upon different sets of abilities. This hypothesis was substantiated for power of reading based on a comparative substrata analysis of the working systems of boys and girls at the high school level (Holmes & Singer, 1961).

General Open Systems Theory Postulate V: Dynamic interplay of the subsystems. The dynamic interplay of subsystems is well described by Menninger, Mayman, and Pruyser (1963):

A hierarchy of levels can be recognized, each with its own mode and means of homeostatic regulation, interrelated by an over-all homeostatic tendency (p. 65).

Five specific interactions of the various subsystems are indicated by Luby (1962): a receptor system for external stimuli; a receptor system for internal stimuli including those from muscles, joints, and viscera; a system for filtering the diverse sensory input and integrating and interpreting it; an effector system involving autonomic and volitional motor acts; a chemical energy production system necessary for the adequate evocation of reactions in each of the separate systems mentioned.

The Substrata-Factor Theory postulates that the various substrata factors are tied together in a working system; and as their interfacilitation in the working system increases, the efficiency of the child's reading also improves. Such diverse substrata factors initially become associated in a particular working system by the psycho-catalytic action of mobilizers--hypothetical constructs which are deep-seated value systems (Holmes, 1959).

General Open Systems Theory Postulate VI: Feedback process. The feedback concept has been highlighted by cybernetics in terms of servomechanisms, i.e., some device that controls some variable in a special way by comparing its actual value with a desired reference value.

Recently, Fender (1964), a professor of biology and electrical engineering, has described the human body as a collection of servomechanisms. Feedback critical systems regulate such functions as body temperature, constitution of body fluids, the flow of blood to the organs and extremities, and the rate of breathing to the level of physical activity.

Fender did an intensive microscopic analysis of the control mechanism of the eye and found that the microscopic structure of the retina is similar to that of the brain. In fact, he notes, the retina is part of the brain that became detached in the course of evolution (1964, p. 32).

The implication of Fender's systems analyses of the eye enhances the idea that the retina contains not only light-sensitive rods and cones but also bipolar cells,

amacrine cells, and ganglia which may equip it to process some information in its own right. The eyes are not merely a reflector of higher mental process or a mechanical camera. (See also Granit, 1955.)

The Substrata-Factor Theory postulates a continuous monitoring of the meaningful material in order for mobilizers to effect the successive compensations necessary within the working systems as they fluctuate around their hypothetical steady states.

General Open Systems Theory Postulate VII: Progressive segregation and hierarchical order of subsystems. This postulate is very similar to the organismic-holistic orientation of Werner and Kaplan who assume". . . that organisms are naturally directed towards a series of transformations--reflecting a tendency to move from a state of relative globality and undifferentiatedness towards states of increasing differentiation and hierarchic integration" (1963, p. 7).

Further, Werner and Kaplan maintain that, with the attainment of higher levels, lower-level functions are not lost but under normal circumstances subordinated to more advanced levels of functioning. Under special conditions, such as dream states, pathological states, intoxication, drugged states, various experimental conditions or confrontation with especially difficult and novel tasks a partial return to more primitive modes of functioning before progressing towards higher-level operations may be evidenced. This tendency has been described by Werner (1948) as the genetic principle of spirality.

The Substrata-Factor Theory postulates the gradient shift in perceptual-conceptual differentiation within and between kinesthetic-auditory and visual modes of learning. There is continual interaction between the whole and its parts. As the parts become more differentiated and meaningful, so does the whole; and as the whole becomes more meaningful, so do its parts (Holmes, 1953, Ch. 32, p. 7).

What constitutes part and whole is a perennial scientific problem continually being analyzed by the nature of scientific reduction. In any scientific observation what is taken as the whole and what, as the parts? The history of science indicates that the answers to this question are inextricably bound up with the personal preference of the experimentalist, his concepts of causality, the culture he belongs to, the Zeitgeist of the

times he lives in, and the nature of the material or experiment.

General Open Systems Theory Postulate VIII: Progressive integration. Postulate VIII develops from Postulate VII; with the continued organization of smaller subsystems into functional hierarchies, a more integrative supersystem also emerges.

Each of the constituent subprocesses must be thought of as integral parts of the whole that work together and contribute proportionately to its total in each and every situation in which the supersystem works.

By additive processes, series-combinations of suitable systems, interlaced with parallel-combinations as desired, may be constructed into larger and larger systems. Thus, hierarchies of subsystems may be developed: subsystem of subsystem of subsystem, etc. (Ellis & Ludwig, 1962, p. 11).

Miller, Galanter, and Pribram come to grips with the supersystem subsystem relationships as follows:

The implication is relatively clear, however, that the molar units must be composed of molecular units, which we take to mean that a proper description of behavior must be made on all levels simultaneously. That is to say, we are trying to describe a process that is organized on several different levels, and the pattern of units at one level can be indicated only by giving the units at the next higher, or more molar, level of description.

For example, the molar pattern of behavior X consists of two parts, A and B in that order. Thus, $X = AB$. But A, in turn, consists of two parts, a and b; and B consists of three, c, d, and e. Thus $X = AB = abcde$, and we can describe the same segment of behavior at any one of the three levels. The point, however, is that we do not want to pick one level and argue that it is somehow better than the others; the complete description must include all levels. Otherwise, the comparative properties of the behavior

will be lost--if we state only abcde, for example, the (ab) (cde) may become confused with (abc) (de), which may be a very different thing.

This kind of organization of behavior is most obvious, no doubt, in human verbal behavior. The individual phenomena are organized into morphemes; morphemes are strung together to form phrases; phrases in the proper sequence form a sentence, and a string of sentences makes up an utterance. The complete description of the utterance involves all these levels. The kind of ambiguity that results when all levels are not known is suggested by the sentence, "They are flying planes." The sequence of phonemes may remain unchanged, but the two analyses (They) (are flying) (planes) and (They) (are) (flying planes) are very different utterances (1960, pp. 13-14).

Holmes utilizes the concept of substrata factors which is a dynamic set of subsystems continually being organized and reorganized in the brain depending on the task confronting the organism. Neurologically, substrata factors are

. . . neurological subsystems of brain cell-assemblies, containing various kinds of information such as memories for shapes, sounds, and meanings of words and word parts, as well as memories for vicarious and experiential material, conceptualizations, and meaningful relationships stored as substantive verbal units in phrases, idioms, sentences, etc. Such neurological subsystems of brain cell-assemblies gain an inter-facilitation, in Hebb's sense (Hebb, D.O. The Organization of Behavior. New York: John Wiley & Sons, 1949, p. 335), by firing in phase. By this means, appropriate, but diverse subsets of information, learned under different circumstances at different times and, therefore, stored in different parts of the brain are brought simultaneously into awareness

when triggered by appropriate symbols on the printed page. These substrata factors are tied together in a working-system, and as their interf facilitation in the working-system increases, the efficiency of the child's reading also increases (1960, p. 116).

Related to the hierarchy of subsystems upon which General Open Systems Theory and Substrata-Factor Theory depend is the assumption of multicausality or reciprocal causation.

McEwen (1963, p. 337) refers to reciprocal causation as the reversibility of cause-effect relations. Physical events are relatively free from reciprocal influence; but biological and sociocultural situations often mutually determine each other.

MacIver notes that "one can reverse with some degree of truth almost any statement of social causation." He illustrates this as follows:

Does the kind of education account for the standard of intelligence in a community?
True, but does not the standard of intelligence account for the standard of education?
(1942, p. 68).

Neurath (1938) called this postulate 'reciprocity-mutual causation' and abandoned it because it makes sociocultural data too "clumsy and perplexing."

In contrast to such a conception of multiple causation, there are the monocausal models of Watson's conditioned reflex or Freud's sexual compulsion and Marx' economic determinism. As Feigl has sagaciously noted:

. . . in most of the significant applications we must remember that it is an entire set of conditions that represents "the cause of an event" and that what we may abstract as "cause" or "effect" in a complex situation is usually only some factor, aspect, magnitude, etc., that we select from a more complex (and possibly inexhaustible) welter of factual details (1953, p. 410).

Hook (1937) calls for a "functional theory of causation together with all the apparatus of statistical inquiry" and for "developing a theory of measurement to determine the relative weight of various causal factors considered." Only a multicausal theory could "offer an explanation of the correlations found."

The substrata factor analysis which is the statistical model supporting the Substrata-Factor Theory accepts the reciprocal causation postulate. Statistically, a substrata analysis consists of Holmes' extension of the Wherry-Doolittle Multiple Selection Technique. The W-D-H substrata analysis

- (a) yields successive sets of subvariables,
- (b) gives each set a definite place in a complex hierarchy of subabilities, and
- (c) discovers statistically significant contributions which each of the subabilities in the hierarchy makes to the criteria immediately above it in the over-all hierarchy of skills and also to the major criterion itself.

Figure 1 shows the generalized schema of a substrata analysis. The studies to date, however, take into consideration only the X on Y regression. Hence, while the Substrata-Factor Theory postulates reciprocal causation and makes provisions for such analyses in the design of the 7094 digital computer program for a substrata analysis, the actual analyses, to date, have been in only one direction. Since cause and effect cannot be directly inferred from either simple or multiple correlation, the postulate of reciprocal cause and effect cannot be either substantiated or refuted on the basis of a statistical substrata analysis.

On the other hand, all knowledge possessed by a normal individual and all mental processes within the same individual must be actively associated or at least may become associated by an existing mental mechanism in the brain. The actual degree to which they are associated on the average may be expressed by the coefficient of correlations. While correlations cannot in any way substantiate reciprocal cause and effect relationships, the correlational analysis can and does give an estimate

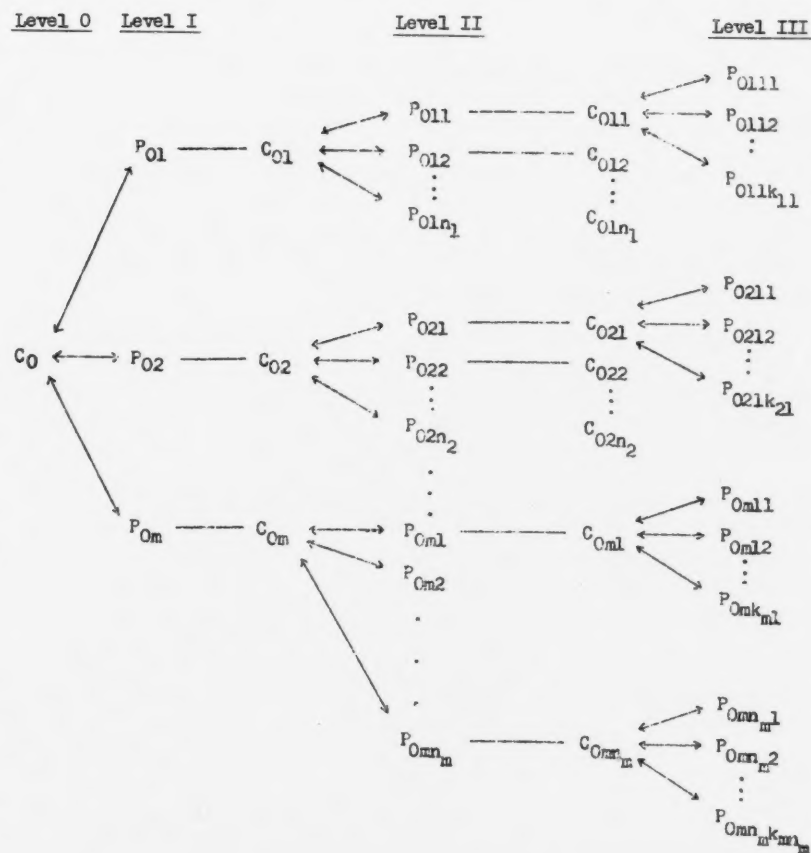


Fig. 1. Schematic Diagram with generalized notation of a substrata analysis through three levels.

Major criterion C_0 is undergirded by substrata factors $P_{01}, P_{02}, \dots, P_{0m}$. Each of these rest on a wider base at Level II. Likewise, at Level III the base is even broader. $P_{0m} \text{ --- } C_{0m}$ terminology is used to indicate an identity, except that what was considered a predictor is in turn considered a subcritierion.

From: Holmes, J. A., & Singer, H. The substrata-factor theory: substrata factor differences underlying reading ability in known-groups at the high school level. U. S. Office of Education Contracts 538, SAE-8176 and 538A, SAE-8660, 1961, 59.

of the reciprocal interactions that may be going on among the variables.

In addition to hierarchical organization of sub-systems' reciprocal causation is a need to reformulate the dependent-independent variable nexus. The dependent variable is (a) the response or criterion; and/or (b) the symbol whose values are determined by the other variables linked with it in an algebraic equation. The independent variable is (a) any variable which is not the criterion variable; and/or (b) the variable which is not dependent upon changes in any other variable.

However, in educational psychology there is no such thing as an absolutely independent variable. The "independent" variables usually identified with environmental conditions or personal characteristics are reciprocally dependent and often statistically related.

The fundamental relation of all variables may be expressed in the form $Y = f(X)$, which reads "Y is a function of X", and means that Y changes in a way to be discovered and/or stated whenever X changes (English & English, 1958, p. 578).

The question of when a variable should be regarded as an independent or "causal" variable and when as the dependent or "resultant" variable is, in the final analysis, left to the judgment of the experimenter. (Ezekiel & Fox, 1959).

The choice of the metaphors used by General Open Systems Theory and the Substrata-Factor Theory for this investigation has been guided by the following characteristics of human beings which Hearn (1958) outlined so well:

1. Humans exchange material with their environment, in the form of both energy and information.
2. This energy may arise either from within the system or from the environment of the system.
3. Human behavior is purposive.
4. When considered both as individuals and as species, humans have a characteristic state toward which they move.

5. Humans may achieve their same characteristic state from different initial conditions and from varying inputs of energy and information.
6. In the human individual as well as in human aggregations such as groups and communities, there is a dynamic interplay among their essential functional processes enabling them to maintain a steady state.
7. There is a tendency in human systems toward progressive mechanization; that is, in the course of human development, certain human processes tend to operate more and more as fixed arrangements.
8. Human systems show a resistance to any disruption of their steady state.
9. They are capable, within limits, of adjusting to internal and external changes.
10. They can regenerate damaged parts.
11. They can reproduce their own kind.

Part II

The empirical aspects of this study are related to a systems analysis as defined by Peach (1960) and Ryans (1964):

By systems study or systems analysis will be meant observation directed at the determination of relevant elements of a system and their operations and interactions as they contribute to the relative efficiency with which the system outcome is produced. It will be necessary to identify and analyze properties and subsystems in order to determine chains of influence which contribute to activities and elements, and it will be necessary to put these pieces together and to synthesize the information to describe the larger systems in which our interests may be focused (Ryans, 1964, p. 23).

Specifically, Part II is concerned with determining the answers to this problem: When each of the content areas are in turn used as criterion tasks, how do the remaining content area subsystems relate to the particular subject matter under consideration? To what degree does each of the content areas co-vary with the rest of the independent variables?

It is hypothesized that working system hierarchies for each of the content areas will manifest quantitative and qualitative differences in the organization sequences as well as magnitudes of the various subsystems.

The Substrata Analysis Method

The statistical method used to infer working-systems is a substrata analysis, an extended form of the Wherry-Doolittle Multiple Test Selection Technique. Wherry (1931, 1940a & b, 1947) and Stead and Shartle (1940) modified the Doolittle least squares technique (1878) so that the variables selected would be only those which were most independent of those already chosen and would, therefore, tend to make a maximum contribution to the multiple prediction of a criterion. The selection process stops when more chance error than predictive variance would have been contributed by the selection of another predictor.

Holmes' (1948) extension, the substrata analysis, repeats the Wherry-Doolittle procedures using each predictor as a subcriterion. The preferential predictor selected at each level becomes in turn a subcriterion at a subsequent level to be analyzed by predictors selected from the remainder of the correlation matrix. Reiteration at present extends to three levels.

Consistent with the second major purpose of the study which forms the basis of this paper, nine substrata analyses took each content area as a criterion in order to determine what proportion of intraindividual variance is accounted for by the remaining content area subsystems. Two of the nine areas analyzed, Power of Reading and Vocabulary in Isolation, are presented here.

Table 1
Intercorrelations, Means, and Standard Deviations of
Content Areas for Subsystem Interaction Analysis
(N = 120)^a

No. Variables ^b	1	2	3	4	5	6	7	8	9	Index of reliab ^c
1 Power of Rdg. —		.823	.693	.718	.576	.695	.663	.486	.548	.93
2 Vocab. in Isol.			.734	.795	.713	.664	.679	.387	.499	.95
3 General Info. ^d				.720	.587	.721	.697	.357	.501	.87
4 English Lit.					.565	.691	.649	.312	.465	.90
5 Grammar						.511	.528	.280	.371	.90
6 Geography							.769	.296	.441	.93
7 History-Civics								.311	.450	.84
8 Arith. Rsng.									.586	.91
9 Arith. Fund'ls									—	.95
Mean	101.01	99.72	13.28	95.49	95.37	89.34	85.65	91.97	90.99	
Std. Dev.	11.59	11.89	4.07	13.15	16.50	19.74	15.32	12.35	19.32	

^aCorrelations must be .24 to be significant at the 1% level of confidence.

^bBased on Stanford Achievement Tests administered in Adolescent Growth Study as part of longitudinal analyses at Institute of Human Development, University of California, Berkeley. See: Jones, 1938, 1939a & b, 1958. Tests re-named for theoretical consistency.

^cThe index of reliability gives the maximum correlation possible between the obtained scores and their theoretically true scores. See: Garrett, 1958, p. 349.

^dA subtest from the Terman Group Test of Mental Ability.

Working System Hierarchy of Power of Reading

An examination of the correlation matrix in Table 1 reveals that Vocabulary in Isolation has the highest zero-order correlation with the criterion Power of Reading ($r = .823$). Therefore, Vocabulary in Isolation will be selected as the first predictor test by the Wherry-Doolittle Test Selection Method. Since r^2 in this instance equals .6773, Vocabulary in Isolation cannot account for more than 67.73 per cent of the criterion's variance. However, 67.73 per cent needs to be corrected in terms of the other predictors which the method selects as well as the bias which arises from chance factors characteristic of sampling and selection techniques.

Specifically, when the contributions of all the selected predictors to criterion variance are computed, Vocabulary in Isolation will account for less of that variance than the value of r^2 . This is due to the calculation of the beta weights for this particular predictor in addition to the other variables which make independent contributions to the variance of the criterion. These variables will take from the Vocabulary in Isolation subsystem some of the variance which this "most valid" predictor appears to have contributed to the Power of Reading criterion by being selected as the first test. In terms of the Substrata-Factor Theory the "... immediate problem is to discover which of the other variables in the matrix will be selected along with (Vocabulary in Isolation) as those variables at Level I which can be thought as having a direct and joint influence" (Holmes and Singer, 1961, p. 81) in the variation of ninth grade students' scores in Power of Reading. After Level I predictors have been selected, the next step is to use these predictors as subcriteria and determine what preferential predictors underlie these at Level II.

A pictorial display of the interaction among the various subject-matter subsystems in the working system of Power of Reading is presented in Figure 2. The major criterion, Power of Reading, is placed on the left under Level 0. Arrayed from left to right are the subject-matter subsystems selected by the substrata analysis. The path of the regression relationships between subsystems is indicated by unidirectional arrows. Mutual interaction representing interaction equally assigned in both directions is shown by double-ended arrows. The numbers adjacent to the unidirectional and bidirectional arrows

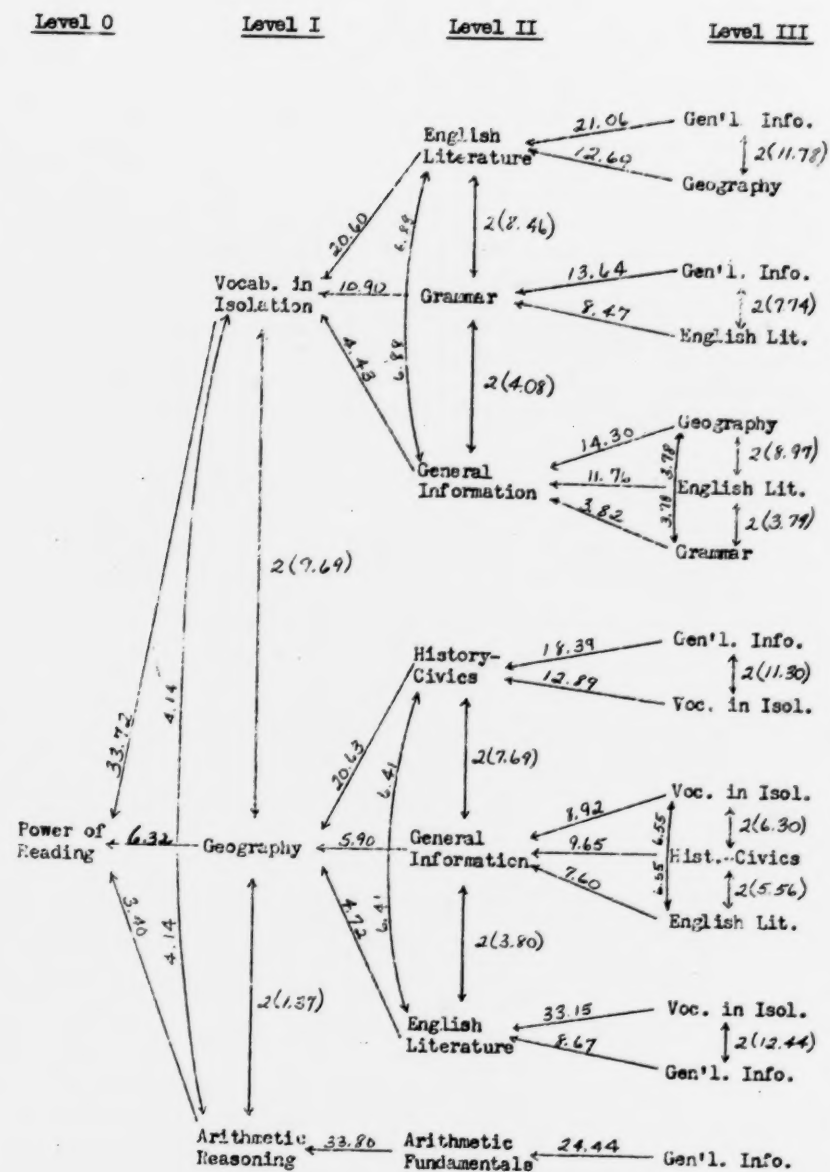


Fig. 2. Schema showing interaction among subject matter subsystems in the working system of Power of Reading; figures represent adjusted proportional variance as per cent.

indicate the relative strength of the interaction accounted for by each subject matter subsystem.

The content area subsystem, the substrata sequence, and the per-cent contribution to variance in Power of Reading at the ninth-grade level can be read from Fig. 2 as follows:

Beginning with Power of Reading, the major criterion, one can see that three subsystems precipitated from the substrata analysis to account for 73.84% of the variance in Power of Reading. The total contribution (direct plus shared variance) to Power of Reading made by each of the content areas is 47.55% by Vocabulary in Isolation, 17.38% by Geography, and 8.91% by Arithmetic Reasoning. By referring to Figure 2 one can see that

Vocabulary in Isolation can be further analyzed into

Direct variance to Power of Reading	33.72
Shared variance with Geography.....	9.69
Shared variance with Arith. Reasoning.....	<u>4.14</u>
Direct plus Shared Variance	47.55

Geography can be analyzed into

Direct variance to Power of Reading.....	6.32
Shared variance with Vocab. in Isolation.....	9.69
Shared variance with Arith. Reasoning.....	<u>1.37</u>
Direct plus Shared Variance	17.38

Arithmetic Reasoning can be broken down into

Direct variance to Power of Reading.....	3.40
Shared variance with Vocab. in Isolation.....	4.14
Shared variance with Geography.....	<u>1.37</u>
Direct plus Shared Variance	<u>8.91</u>
Total contribution to Power of Reading	73.84%

At the Level II analysis, with Vocabulary in Isolation as the subcriterion, English Literature, Grammar, and General Information account for 74.77% of Vocabulary in Isolation's variance. Now, with English Literature as the subcriterion, two subsystems, General Information and Geography, account for 57.13% of English Literature's variance. The other branches of the schema shown in Figure 2 can be read in a similar manner.

Summary of Substrata Analysis of Power of Reading

Power of Reading is a complex suprasystem dependent upon interrelationships of various subject-matter subsystems. Vocabulary in Isolation accounts for nearly half of the variance which creates individual differences in Power of Reading at the ninth-grade level. Geography and Arithmetic Reasoning, functioning either directly or indirectly, account for another 25% of the variance in Power of Reading. Not accounted for and probably intrinsic to Power of Reading or not measured in this study, is approximately 24% of the variance in Power of Reading. The remaining subject-matter subsystems are systems within systems, and the substrata analysis reveals the extent to which these subsystems interact with each other as well as the major criterion, Power of Reading.

Working System Hierarchy of Vocabulary in Isolation

The substrata analysis of Vocabulary in Isolation will provide information about the hierarchical organization of this suprasystem. Although Vocabulary in Isolation and Power of Reading correlate .8226 with each other, the major concern is with the substructural relationships underlying each of these complex subject-matter areas. While it is expected that there will be much overlap between Vocabulary in Isolation and Power of Reading, it is also anticipated that the substrata analysis will reveal constellations of subsystems which will show quantitative and qualitative differences in interaction among the various subsystems.

Level I: Substrata Analysis of Vocabulary in Isolation. The correlation matrix, Table 1, was submitted to the W-D-H Test Selection Method in order to determine the primary subsystems which underlie the ability to do well in a Vocabulary in Isolation test appropriate to the junior high school level.

Table 2, section A, presents the direct and shared variance among the subsystems selected to predict the criterion, Vocabulary in Isolation. When the beta weights are combined with the zero-order correlations, corrected for chance fluctuations according to the shrinkage formula and multiplied by 100, it is found that three subject-matter areas account for 80.77% of the variance of Vocabulary in Isolation and break down in the following manner:

- (1) Power of Reading contributes 34.35%,
- (2) English literature accounts for 26.45%, and
- (3) Grammar explains 19.97% of the variance.

It is interesting to note that the variance which English Literature and Grammar share indirectly with Power of Reading is about equal to the direct association of these subsystems with Vocabulary in Isolation. It is reasonable to infer that proficiency in these subject-matter systems in itself is not sufficient basis for the attainment of high achievement in Vocabulary in Isolation; relationships among the subject-matter systems will enhance performance on Vocabulary in Isolation.

Level II: Substrata Analysis of Vocabulary in Isolation. Consistent with the statistical model of the substrata analysis, it is relevant to ask what subsystems of subject-matter variables underlie each of the predictors just reported for Power of Reading, English Literature, and Grammar?

To answer this question, a substrata analysis was made deleting Vocabulary in Isolation from the zero-order correlation matrix in Table 1 and allowing each of the predictors for Vocabulary in Isolation to become a sub-criterion for a Level II-substrata analysis on all the remaining variables.

Table 2, Section B, presents the regression relationship of the various subject-matter subsystems selected to predict the subcriterion, Power of Reading. This portion of the table is read the same way as the previous analysis of Vocabulary in Isolation at Level I. Three content areas, English Literature, Arithmetic Reasoning, and Geography, account for Power of Reading. The three predictors directly indicate that a bit more than half of the variance is accounted for by Power of Reading. The remainder of the variance is distributed among the content areas.

The second subsystem predicting Vocabulary in Isolation is English Literature, which is now used as a subcriterion. General Information and Power of Reading account for 60.41% of the direct and shared variance of English Literature. Each of these subsystems accounts for about an equal amount of the variance, or 30.53% and 29.88%, respectively.

Table 2

Substrata Analysis of Vocabulary in Isolation--Subsystem in the Order
Selected and the Accounted-for Portion of Variance Directly
Associated With, and Shared Among, the Subsystems at Levels I, II, III
(N = 120)

Criterion	Subsystem selected	Correl. w/crit.	Beta	Adj. Prop. Direct to:	Variance	(as per cent) Shared from:		
Section A								
Level 0	Level I			Voc.I	Power	Lit.	Gram.	Total
Voc. in Isol.	Pwr. of Rdg.	.8226	.42	17.54	0.00	10.03	6.78	34.35
	English Lit.	.7952	.33	11.13	10.03	0.00	5.29	26.45
	Grammar	.7129	.28	7.90	6.78	5.29	0.00	19.97
	Variance accounted for:			36.57	16.81	15.32	12.07	80.77
Section B								
From Vocabulary in Isolation at Level 0 to:								
Level I	Level			Power	Lit.	A.Rsg	Geog.	Total
Pwr. of Rdg.	English Lit.	.7177	.40	15.90	0.00	3.20	9.31	28.41
	Arith. Rsg.	.4855	.26	6.65	3.20	0.00	2.58	12.43
	Geography	.6947	.34	11.43	9.31	2.58	0.00	23.32
Variance accounted for:				33.98	12.51	5.78	11.89	64.16
Level I	Level II			Lit.	G.Inf	Power		Total
English Lit.	Gen'l Info.	.7201	.43	18.17	0.00	12.36		30.53
	Pwr. of Rdg.	.7177	.42	17.52	12.36	0.00		29.88
	Variance accounted for:			35.69	12.36	12.36		60.41
Level I	Level II			Gram.	G.Inf	Power		Total
Grammar	Gen'l Info.	.5869	.36	12.67	0.00	7.95		20.62
	Pwr. of Rdg.	.5765	.33	10.40	7.95	0.00		18.35
	Variance accounted for:			23.07	7.95	7.95		38.97
Section C								
From Vocab. in Isol. through <u>Power of Reading</u> at Level I to:								
Level II	Level III			Lit.	G.Inf.	Geog.		Total
English Lit.	Gen'l Info.	.7201	.46	21.06	0.00	11.78		32.84
	Geography	.6912	.36	12.69	11.78	0.00		24.47
	Variance accounted for:			33.75	11.78	11.78		57.31
Level II	Level III			A.Rsg	A.Fun			Total
Arith. Rsg.	Arith. Fund.	.5861	.59	33.80	0.00			33.80
Variance accounted for:				33.80				33.80

(Table continued on next page)

Table 2 (Continued)

Criterion	Subsystem selected	Correl. w/crit.	Beta	Adj. Prop. Direct to:	Variance (as per cent) Shared from:				
Level II	Level III			Geog.	Hs-Cv	G. Inf.	Lit.	Total	
Geography	Hist.-Civics	.7693	.46	20.63	0.00	7.69	6.41	34.73	
	Gen'l Info.	.7205	.24	5.90	7.69	0.00	3.80	17.39	
	English Lit.	.6912	.22	4.72	6.41	3.80	0.00	14.93	
	Variance accounted for:			31.25	14.10	11.49	10.21	67.05	
From Vocab. in Isol. through English Literature at Level I to:									
Level II	Level III			G. Inf.	Geog.	Power	Gram.	Total	
Gen'l Info.	Geography	.7205	.42	17.15	0.00	8.00	4.45	29.60	
	Pwr. of Rdg.	.6925	.28	7.74	8.00	0.00	3.37	19.11	
	Grammar	.5869	.21	4.41	4.45	3.37	0.00	12.23	
	Variance accounted for:			29.30	12.45	11.37	7.82	60.94	
Level II	Level III			Power	Geog.	A. Rsg	G. Inf	Gram.	Total
Pwr. of Rdg.	Geography	.6947	.35	12.24	0.00	2.49	6.05	3.29	24.07
	Arith. Rsg.	.4855	.24	5.77	2.49	0.00	2.06	1.24	11.56
	Gen'l Info.	.6925	.24	5.76	6.05	2.06	0.00	2.59	16.46
	Grammar	.5765	.19	3.38	3.29	1.24	2.59	0.00	10.50
	Variance accounted for:			27.15	11.83	5.79	10.70	7.12	62.59
From Vocab. in Isol. through Grammar at Level I to:									
Level II	Level III			G. Inf.	Geog.	Lit.	Hs-Cv	Total	
Gen'l Info.	Geography	.7205	.28	7.54	0.00	6.98	5.12	19.64	
	English Lit.	.7201	.37	13.52	6.98	0.00	5.78	26.28	
	Hist.-Civics	.6974	.24	5.87	5.12	5.78	0.00	16.77	
	Variance accounted for:			26.93	12.10	12.76	10.90	62.69	
Level II	Level III			Power	Lit.	A. Rsg	Geog.	Total	
Pwr. of Rdg.	English Lit.	.7177	.40	15.90	0.00	3.20	9.31	28.41	
	Arith. Rsg.	.4855	.26	6.65	3.20	0.00	2.58	12.43	
	Geography	.6947	.34	11.43	9.31	2.58	0.00	23.32	
	Variance accounted for:			33.98	12.51	5.78	11.89	64.16	

The third-subject matter system which predicts Vocabulary in Isolation is Grammar. A substrata analysis of Grammar reveals that General Information and Power of Reading account for 38.97% of the direct and shared variance. Three fifths of the variance is accounted for by the two subsystems in direct association with Grammar. The remaining variance is shared between General Information and Vocabulary in Isolation. Most of the variance, 61.03%, remains to be accounted for.

Level III: Substrata Analysis of Vocabulary in Isolation. The substrata analysis is continued from Vocabulary in Isolation through Power of Reading at Level I to English Literature at Level II, which is now set as a subcriterion.

At Level III, two subsystems, General Information and Geography, precipitate to predict the variance in English Literature.

Table 2, Section C, shows that the two systems account for 57.31% of the total variance in English Literature. The direct and shared variance as well as the total variance is identical to that found for English Literature in a Level III substrata analysis when Power of Reading is the major criterion. This illustrates that each subsystem has an integrity of its own and yet bears a relationship within a larger suprasystem of knowledge.

Arithmetic Reasoning is the next subcriterion to be analyzed. As in the substrata analysis of Power of Reading, Arithmetic Fundamentals is the only system precipitated, accounting for 33.80% of the variance.

The third subcriterion is Geography. Although this subsystem is analyzed at Level III, the variables precipitated and the amount of variance accounted for are identical to those found for Geography at Level II, when Power of Reading was the major criterion.

All the predictors precipitated from the three subsystems, English Literature, Arithmetic Reasoning, and Geography, in the working system hierarchy of Vocabulary in Isolation account for an identical amount of the direct and shared variance. This parallels what was found when these subsystems were subcriteria in the substrata analysis of the working system of Power of Reading.

Figure 3 shows the interaction among the subject-matter subsystems and the suprasystem, Vocabulary in Isolation. However, because the substrata sequence in which the three subsystems are represented in the working system hierarchy of Power of Reading and Vocabulary in Isolation are different; the predictors precipitated in each of the three subsystems also make different contributions to their respective major criteria.

Table 3 presents the relevant parallel branches of the working-system hierarchies of Power of Reading and Vocabulary in Isolation in order to show the substrata sequences which provide a basis for prorating the variance accounted for in the major criterion from either Levels I, II, or III.

By using the sequential proration technique developed by Holmes (Holmes & Singer, 1961, 1965) the following is accomplished:

1. Each substrata factor's contribution to the variance in the working-system hierarchy of a given major criterion is determined regardless of the level at which it was precipitated.
2. Residuals are taken into account.
3. Particular predictors that were precipitated more than once at a given level can be accumulated, thus presenting a more concise picture of the working-system.
4. Comparisons can be made between other substrata factors precipitated in the various working system hierarchies of this study as well as other studies.

It is apparent that the second major purpose of this investigation has been substantiated, namely, that there are quantitative and qualitative differences among the subject-matter supra- and subsystems.

The reciprocal interaction that one system has on another may be inferred from an analysis of X on Y and Y on X regression equation. That reciprocity need not be symmetrical, as has been suggested by Holmes (1964a) and given theoretical neurological support by John (1962, p. 86). An indication of this non-symmetrical interaction

Table 3
Comparative Substrata Sequences and Prorated Distribution of
Percentage of Criterion Variance in the Working Systems of
Power of Reading and Vocabulary in Isolation

Sequences of substrata factors and their per cent contributions at each level of analysis						Prorated Dist. of percentage of criterion variance ^a	
Level 0	Level I	%	Level II	%	Level III	%	
Power (See Fig. 2)	1. Voc.I	47.55	a. Lit.	35.94	1) G. Inf.	32.84	5.61
					2) Geog.	24.47	4.18
						57.31	9.79
	2. Geog.	17.38	a. Hs-Cv	34.73			6.04
					b. G. Inf	17.39	3.02
					c. Lit.	14.93	2.59
						67.05	11.65
	3. A.Rsg	8.91	a. A. Fun	33.80			3.01
Level 0	Level I	%	Level II	%	Level III	%	
Voc.I (See Fig. 3)	1. Power	34.35	a. Lit.	28.41	1) G. Inf	32.84	3.21
					2) Geog.	24.47	2.38
						57.31	5.59
			b. A.Rsg.	12.44	1) A. Fun	33.80	1.46
	c. Geog.			23.32	1) Hs-Cv	34.73	2.84
					2) G. Inf	17.39	1.41
					3) Lit.	14.93	1.21
						67.05	5.46

^aThe prorated distribution of percentage of criterion variance is calculated by multiplying together the contributions to variance at each successive level by analysis. For example, General Information contributes 32.84% to the variance of English Literature, which, in turn, contributes 35.94% to the variance in Vocabulary in Isolation, and Vocabulary in Isolation contributes 47.55% to the variance in Power of Reading. Thus, $.3284 \times .3594 \times .4755 \times 100$ equals 5.61%, the contribution made by General Information through this substrata sequence, over and above that per cent of variance contributed through other substrata sequences.

is shown by using Power of Reading as the major criterion, or dependent variable, and Vocabulary in Isolation as the predictor, or independent variable, for an X on Y regression. The converse, or Y on X regression equation, is applied by using Vocabulary in Isolation as the major criterion, or dependent variable, and Power of Reading as the independent variable. This approach to non-symmetrical interaction is summarized in Table 4.

Table 4
Non-Symmetrical Reciprocal Interaction Between
Power of Reading and Vocabulary in Isolation

Dependent variable	Independent variable	Correl. Dv vs. Iv	Adj. Prop. Variance		
			Direct	Shared	Total
Power of Reading	Vocab. in Isolation	.8226	33.72	13.83	47.55
Vocab. in Isolation	Power of Reading	.8226	17.54	16.81	34.35

John (1962, pp. 86-87) attempts to explain reciprocal interaction in terms of a physiological model for simple conditioned responses as follows:

While reciprocity of the interaction is suggested, this reciprocity need not be symmetrical, particularly when the associated discharges did not occur simultaneously in two particular foci. Assume that if a definite dominant focus is established in an area due to associated discharge of a group of neurons, afferent activity propagated into the region has an increased probability of achieving markedly nonrandom discharge from the focal area. The more recent the previous associated discharge which activated the focus, the higher the probability of subsequent nonrandom discharge which might be expected. Thus, activity propagating through a network from some region A, where associated discharge of an aggregate occurred earlier in time, might occasion markedly nonrandom discharge of some region B organized into a dominant focus by a more recent strong input from another origin. Conversely, the activity propagating through the network from the discharge of this strong focus B, established later in time than A will subsequently enter the region A. While some cells in region A may well be responsive to this input originating at B, discharge

in region A is likely to be more random than at B because more time has elapsed since the focus was established, excitability of neurons in the region is more likely to have deviated from the common state, and thus the strength of the group discharge tendency is lowered.

In terms of the far greater impact of Vocabulary in Isolation, 33.72% direct variance on Power of Reading in contrast to Power of Reading's impact on Vocabulary in Isolation to the extent of 17.14% direct variance, it appears that the strength of the neural aggregate discharge is not only a function of recency, but also of the following neurological and psychological reasoning adopted and extended from John (1962, p. 86).

1. Vocabulary is the sine qua non of reading comprehension. If there is no vocabulary, there can be no comprehension.
2. Although Vocabulary in Isolation is taught earlier than Power of Reading, its repeated association will increase the strength of neural aggregate discharge.
3. By repeated association Vocabulary in Isolation reaches a more "significant level of activation" (John, 1962, p. 86) than Power of Reading.
4. The very high correlation between Vocabulary in Isolation and Power of Reading may also indicate
 - a. a particular temporal pattern that has characterized the mode of discharge of the system and
 - b. that various neural aggregates which have been associated during the establishment of a system constitute a set of reciprocally interlocked dominant foci.

The foci and the relationships between them constitute a representation of the configuration of central excitations which have been so associated. Such a system of interrelated dominant foci will subsequently be referred to as a representational system (John, 1962, p. 86).

John's representational system is equivalent to Holmes' working system (1948). And John's neurologizing is consistent with Holmes' (1957) model of the workings of the brain during the reading process.

A representational system of the dominant foci in the working-system hierarchy of Vocabulary in Isolation is displayed in the schema shown in Figure 3. The schema is read in the same manner as Figure 2, which represents the working system of Power of Reading.

Summary of Substrata Analysis of Vocabulary in Isolation

A substrata analysis of Vocabulary in Isolation reveals a complex suprasystem undergirded by subsystems within subsystems of dominant foci at Levels I, II, and III. A comparison of the substrata sequences in the working systems of Power of Reading and Vocabulary in Isolation indicates that although the subsystems English Literature, Arithmetic Reasoning, and Geography have identical direct and shared variances within their respective subsystems, a sequential proration based upon the multiplier principle indicated that the three subsystems make different contributions to the variance of their major criterion.

The logic of the proration approach is given in terms of two basic postulates which assume that substrata factors are composed of systems within subsystems and, secondly, correlation reflects a mean, reciprocal interaction among two such subsystems.

Symmetrical and non-symmetrical interaction is further postulated with an analysis of X on Y and Y on X for Power of Reading and Vocabulary in Isolation. Non-symmetrical contributions to variance are found and explained by extending John's (1962) neurophysiological model and the author's psychological reasoning about the interaction of Power of Reading and Vocabulary in Isolation.

SUMMARY AND CONCLUSIONS

Basic Postulates of General Open Systems Theory and the Substrata-Factor Theory of Reading: Because the integrating construct of this study was General Open Systems Theory and the Substrata-Factor Theory, fundamental postulates common to the two theories were presented. Eight postulates were identified.

- Postulate I: Exchange of energy, information, or matter with the environment through input and output channels
- Postulate II: Maintenance of steady states
- Postulate III: Self-regulating tendencies-re-establishment of steady states after being disturbed
- Postulate IV: Equifinality
- Postulate V: Dynamic interplay of the subsystems
- Postulate VI: Feedback processes
- Postulate VII: Progressive segregation and hierarchical order of subsystems
- Postulate VIII: Progressive integration

Assumptions

Several fundamental assumptions had to be made in order to proceed with the substrata analyses:

1. Content areas examined in this study are complex suprasystems consisting of many diverse, yet functionally related and supportive, subsystems.
2. Substrata factors are dynamic sets of subsystems continually being organized and reorganized in the brain, depending on the task confronting the organism.
3. Hierarchies of subsystems upon which the substrata analysis is made depend on the concept of multi-causality or reciprocal causation.

4. While correlations cannot in any way substantiate reciprocal cause and effect relationships, the correlational analysis can and does give an estimate of the reciprocal interaction that may be going on among the variables.
5. Reciprocal interaction may be represented by an analysis of the X on Y and Y on X regression equation - for in educational psychology there is no such thing as an absolutely independent variable. Independent variables are reciprocally dependent and often statistically related.
6. The biological sciences, i.e., physiology, biochemistry, and neurology, can provide a framework for further understanding of the psycho-educational results of this study.

Conclusions

Generally, the theoretical and empirical aims of this study were achieved, i.e.,

1. There is an isomorphic relationship between all General Open Systems Theory postulates and Substrata-Factor Theory postulates. Therefore, in terms of the abstracted General Open Systems Theory postulates, the Substrata-Factor Theory exhibits internal consistency and external agreement with similar theories in other disciplines such as biology, chemistry, and physics.
2. Subject-matter areas can be conceived of as suprasystems girded by diverse, yet functionally related, subsystems.

More specifically,

1. Working-system hierarchies were found for each content area manifesting quantitative and qualitative differences in organization of substrata sequences, amount of variance accounted for, and redundancy of particular variables.
2. Reciprocal interaction can be inferred from an X on Y and Y on X regression analysis.
3. The prorotation sequential technique may provide a basis for determining the extent of a

particular subsystem's impact on the suprasystem.

Limitations

This study is a first approximation, and its generalities are limited to the basic assumptions, postulates, sampling, methods, and tests used. Further, theory building, testing, and logical analysis as well as knowledge of the nature of the brain is necessary to more fully understand the present findings as well as subsequent findings.

NOTES

¹This paper is based in part upon a Ph.D. dissertation done by the writer at the University of California (Kling, 1964). The writer wishes to acknowledge the financial assistance of the Carnegie Corporation of New York.

²On a theoretical level Bertalanffy made pioneering inroads in the field of biology. See Bertalanffy, 1928, 1932.

³Personal communication, Holmes (1964b).

REFERENCES

- Allport, F. H. Theories of Perception and the Concept of Structure. New York: Wiley & Sons, 1955.
- Ashby, W. R. An Introduction to Cybernetics. New York: Wiley & Sons, 1956.
- Ashby, W. R. "General Systems Theory as a New Discipline," In L. von Bertalanffy & A. Rapaport (eds.) General Systems Yearbook of the Society for General Systems Research. Ann Arbor, Michigan Mental Health Research Institute, University of Michigan, 1958, B., 1-11.
- Bayle, Evalyn. "Nature and Causes of Regressive Eye Movements in Reading," Journal of Education Psychology, 1942, Vol. 11, 16-35.
- Bertalanffy, L. von. Kritische Theorie der Formbildung. Berlin: Verlag von Gebruder Borntraeger, 1928.
- Bertalanffy, L. von. Theoretische Biologie, Erster Band: Allgemeine Theorie, Physikorhemie, Aufbau und Entwicklung des Organismus. Berlin: Verlag von Gebruder Borntraeger, 1932.
- Bertalanffy, L. von. "Zu Einer Allgemeinen Systemlehre." Blaetter f. Dtsch. Phil., 1945, 18, 3/4.
- Bertalanffy, L. von. Das Biologische Weltbild. Bern: A. Francke, 1949.
- Bertalanffy, L. von. "The Theory of Open Systems in Physics and Biology," Science, 1950, vol. 111, 23-29. (a)
- Bertalanffy, L. von. "An Outlines of General Systems Theory," Brit. J. Phil. Sci., 1950, Vol. 1, 134-163. (b)
- Bertalanffy, L. von. "Theoretical Models in Biology and Psychology," Journal of Personality, 1951, vol. 20, 24-38.
- Bertalanffy, L. von. Problems of Life. New York: Wiley & Sons, 1952.
- Bertalanffy, L. von. "General Systems Theory," Main Currents in Modern Thought, 1955, vol. 11, 75-83.

- Bertalanffy, L. von. In L. von Bertalanffy & A. Rapaport (Eds.), General Systems - Yearbook of Soc. Advanc. Gen. Sys. Theor., Ann Arbor, Mich: Braun-Brumfield, 1956, vol. 1, 1-10.
- Bertalanffy, L. von. "General Systems Theory - A Critical Review." In L. von Bertalanffy & A. Rapaport (Eds.), General Systems - Yearb. Soc. Gen. Sys. Res. New York: The Society; 1962, 1-20. (a)
- Bertalanffy, L. von. Modern Theories of Development. New York: Harper, 1962. (b)
- Bray, H. G. & White, K. "Organisms as Physico-Chemical Machines," New Biology, 1954, vol. 16, 70-85.
- Brodbeck, May. "Models, Meanings and Theories," In L. Gross (ed.), Symposium on Sociological Theory. Evanston, Ill.: Row, Peterson, 1959, 373-403.
- Doolittle, M. H. "Method Employed in the Solution of Normal Equation and the Adjustment of a Triangulation," U. S. Coast & Geodetic Survey Report, 1878, 115-120.
- Ellis, D. O. & Ludwig, F. J. Systems Philosophy. Englewood Cliffs, N. J.: Prentice-Hall, 1962.
- English, H. B. & English, Ava C. A Comprehensive Dictionary of Psychological and Psychoanalytical Terms. New York: Longmans, Green, 1958.
- Ezekiel, M. & Fox, K. A. Methods of Correlation and Regression Analysis Linear and Curvilinear (3rd ed.). New York: John Wiley & Sons, 1959.
- Fechner, G. T. Einige Ideen zur Schöpfungs und Entwicklungsgeschichte der Organismen. Leipzig: Breitkopf und Härtel, 1873.
- Feigl, H. "Notes on Causality," in H. Feigl & May Brodbeck (eds.), Readings in the Philosophy of Science. New York: Appleton-Century-Crofts, 1959, 408-418.
- Fender, D. H. "Control Mechanisms of the Eye," Scientific American, 1964, vol. 211 (1) 24-33.
- Gagné, R. M. (ed.) Psychological Principles in System Development. New York: Holt, Rinehart & Winston, 1962.

- Granit, R. Receptors and Sensory Perception. New Haven: Yale Univ. Press, 1955.
- Hearn, G. Theory Building in Social Work. Toronto: University of Toronto Press, 1958.
- Holmes, J. A. Factors Underlying Major Reading Disabilities at the College Level. Unpublished doctoral dissertation, University of California, Berkeley, 1948.
- Holmes, J. A. The Substrata-factor Theory of Reading. Berkeley: California Book Co., 1953. (Out of print)
- Holmes, J. A. "Factors Underlying Major Reading Disabilities at the College Level," Genetic Psychology Monograph, 1954, vol. 49, First half, 3-95.
- Holmes, J. A. "The Brain and the Reading Process," in Claremont College Reading Conference, Twenty-second Yearbook. Claremont, Cal.: Claremont College Curriculum Laboratory, 1957, p. 49-67.
- Holmes, J. A. "The Substrata-factor Theory of Reading: Some Experimental Evidence," New Frontiers in Reading, International Reading Association Conference Proc., 1960, vol. 5, 115-121.
- Holmes, J. A. "Creativity and the Substrata-factor Theory." Paper read at American Association of School Administrators, San Francisco, February, 1961. (a)
- Holmes, J. A. "Personality Characteristics of the Disabled Reader," Journal of Developmental Reading, 1961, vol. 4, 111-122. (b)
- Holmes, J. A. "Public Education and Children With Reading Problems." Paper read at Symposium on Reading Disorders, University of California School of Medicine, San Francisco, February, 1963. (a)
- Holmes, J. A. "Creative Writing and Power in Reading," Paper read at National Council for Research in English and the International Reading Association, Miami, May, 1963. (b)
- Holmes, J. A. "Basic Assumptions Underlying the Substrata-factor Theory." Paper read at joint meeting of International Reading Association and American Educational Research Association, Philadelphia, May, 1964. (a)

- Holmes, J. A. Personal communication, July, 1964. (b)
- Holmes, J. A. & Singer, H. The Substrata-factor Theory: substrata factor differences underlying reading ability in known-groups at the high school level. U. S. Office of Education, Cooperative Res. Project, Contracts 538, SAE-8176 and 538A, SAE-8660, 1961.
- Holmes, J. A. & Singer, H. "Theoretical Models and Trends Toward More Basic Research in Reading," Review of Educational Research, 1964, vol. 34, 127-155.
- Holmes, J. A. & Singer, H. Speed and Power of Reading in High School. U. S. Dept. of Health, Education and Welfare. Washington: Gov't. Printing Office, in press. (1965)
- Hook, S. "Determinism," in E. R. A. Seligman & Johnson (eds.), Encyclopaedia of the Social Sciences, vol. 3, New York: Macmillan, 1937, 110-114.
- John, E. R. "Some Speculations on the Psychophysiology of Mind," in J. M. Scher (ed.), Theories of the Mind. New York: Free Press of Glencoe, 1962, 80-121.
- Jones, H. E. "The California Adolescent Growth Study," Journal of Educational Research, 1938, vol. 31, 561-567.
- Jones, H. E. "The Adolescent Growth Study: I. Principles and Methods." Journal Consulting Psychology, 1939, vol. 3, 157-159. (a)
- Jones, H. E. "The Adolescent Growth Study: II. Procedures." Journal of Consulting Psychology, 1939, vol. 3, 177-180. (b)
- Jones, H. E. "Problems of Method in Longitudinal Research," Vita Humana, 1958, vol. 1, 93-99.
- Kling, M. The Generalization of the Substrata-factor Theory to General Open Systems Theory. Unpublished doctoral dissertation, University of California, Berkeley, 1964.
- Luby, E. D., et al. "Model Psychoses and Schizophrenia," American Journal of Psychiatry, 1962, vol. 119, 61-68.

- McEwen, W. P. The Problem of Social-Scientific Knowledge. Totowa, N. J.: Bedminster Press, 1963.
- MacIver, R. M. Social Causation. Boston: Ginn, 1942.
- Maupertuis, P. L. M. de. Cited by K. Menninger, M. Mayman, & P. Pruyser, The Vital Balance. New York: Viking Press, 1963, 81.
- Menninger, K., Mayman, M., & Pruyser, P. The Vital Balance. New York: Viking Press, 1963.
- Miller, G. A., Galanter, E., & Pribram, K. H. Plans and Structure of Behavior. New York: Holt-Dryden, 1960.
- Neurath, O. "Encyclopedia and Unified Science," Internat'l. Encyclopedia of Unified Science, vols. I, II., Foundations of the unity of science. Chicago: University of Chicago Press, 1938, vol. I, No. 1.
- Peach, P. "What is Systems Analysis?" SP-155. Santa Monica, Calif.: Systems Development Corp., 1960.
- Ryans, D. G. "System Analysis in Educational Planning." Paper read at Sixth Annual Institute on College Self-study, Berkeley, July, 1964.
- Sells, S. B. (ed.) Stimulus Determinants of Behavior. New York: Ronald Press, 1963.
- Stead, W. H., Shartle, C. L., et al. Occupational Counseling Techniques. New York: American Book Co., 1940.
- Werner, H. Comparative Psychology of Mental Development. New York: Follet, 1948.
- Werner, H. & Kaplan, B. Symbol Formation. New York: Wiley, 1963.
- Wherry, R. J. "A New Formula for Predicting the Shrinkage of the Coefficient of Multiple Correlation." Ann. math. Statist., 1931, 2, 440-451.
- Wherry, R. J. "An Approximation Method for Obtaining a Maximized Multiple Criterion." Psychometrika, 1940, vol. 5, 109-115. (a)

Wherry, R. J. "The Wherry-Doolittle Test Selection Method." in W. H. Stead, C. L. Shartle, et al., Occupational Counseling Techniques. New York: American Book Co., 1940. pp. 245-252. (b)

Wherry, R. J. "The Wherry-Doolittle Test Selection Method." In H. E. Garrett, Statistics in Psychology and Education. New York: Longmans, Green, 1947, 435-451.

A CRITIQUE OF GENERAL OPEN SYSTEMS THEORY
AND THE SUB STRATA-FACTOR THEORY OF READING

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Like most others I am tremendously impressed by the amount of statistical labor that has been done by means of modern computer technology in manipulating the information in these substrata analyses. But I must admit that I would prefer to see it in a context in which fewer assumptions about the nature of the metaphysical world were involved. First, I would like to discuss my perception of general open systems theory. Judging from the various sets of postulates and assumptions, it seems to me that it is a sort of verbal game involving some statistical manipulations. The game goes something like this - let's make 24 assumptions that we state (and possibly a few more that we do not state), and given an existing set of data, see what we can say about the universe.

Notice that this is an ad hoc kind of argument or explanation. It is a statistical elaboration of existing data, and in spite of Kling's discussion which has indicated that the study has theoretical and empirical aims, it seems to me it is not, strictly speaking, an empirical study. It is true that the author has described a somewhat isomorphic relationship between general open system theory postulates and substrata factor theory postulates. This, of course, is only a theoretical aim and no empirical evidence is either demanded or produced. The second conclusion, however, that subject-matter systems can be conceived of as supra systems, undergirded by diverse, yet functionally related subsystems, is indicated as an empirical finding. I think it is very important to notice the sense in which this is an empirical finding. We ordinarily think of empirical investigations as those in which we attempt to make predictions about events, produce an experimental situation in which data is gathered while experimental variables are manipulated, and then examine a subsequent state of affairs to determine whether or not our experimental manipulations changed anything. In this sense the research reported by Kling is not experimental research. It is experimental only in the sense that it was an effort to find out whether or not subject-matter areas could be conceived in the manner described in the Wherry-Doolittle-Holmes substrata analyses technique.

It seems to me that the only hypotheses that were verified were that the computer was functioning and that it is possible to get correlations between these particular variables. However, that does not seem to me to be a particularly surprising finding. It reminds me of an example that Bertrand Russell once used in which he described the difference between explanation of already existing data and the prediction of future data. He indicated that it would be possible, given a sufficiently complex system, to explain on a purely mathematical basis the numbers on the last 10 license plates to go by. However, as he indicated, this would not necessarily assist you in predicting the numbers on the next license plate to come.

I think it is true that open system theory has been shown here to be applicable to the kind of data that one gets when one gives a set of tasks to a sample of students. However, I find it difficult to see the specific relevance of the open systems theory to the substrata factor theory. Everything that was said about open systems theory could very well have been said as a defense for attacking this data, as many other researchers would have done, using factor analysis techniques.

I think my problem is that I am nervous about a model such as open systems theory which is applicable to any kind of data to which you apply it. The question of whether it is a useful theory in this particular realm of inquiry depends entirely upon the experimental, rather than statistical, designs that it spawns and the utility of the results of those experiments.

Secondly, I want to discuss the notion of substrata factor theory analyses as they are carried out in the Wherry-Doolittle-Holmes statistical design.

First of all it is important to realize that this is not a factor analysis in any of the usual senses of the word. It is precisely the kind of analysis that is routinely done, for example, in our University every year in each of seventeen colleges to predict the "power of performance" of students in college for the purpose of determining which tests might best be used in entrance testing. As a matter of fact, the technique was originally proposed by Wherry and Doolittle as a method of selecting tests for the purpose of selecting people for vocations. It was proposed not as an explanatory system but as a predictive system designed for maximum effective

decision making. It is difficult for me to see decision making, in the sense that Wherry and Doolittle intended, in the kind of analyses that result from the extension that Holmes has produced. The primary difference between the Wherry-Doolittle system of multiple regression analyses and Holmes' is that Holmes carries it out to succeeding steps by taking those predictors which make significant additions to predictive power and using them as criteria to be predicted by the rest of the variables.

It is important to remember several things about this particular prediction model. First, it makes all the usual correlational assumptions about all of the variables. Any relationships in this whole analysis which are not drawn from normally distributed variables on samples randomly drawn from a normal population violate the assumptions inherent in the method.

Second, it is important to realize that the level of relationships exemplified by the Beta weights in such a predictive model are a function of the number of subjects and the number of tests. This, of course, is easy to see. If you had two subjects and two tests, no matter what the results were, you would have perfect prediction and would account for all of the variance.

Third, it is necessary to consider what changes in the predicted variable and changes in the population would mean in this analysis. Figures 1 and 2 show two Wherry-Doolittle analyses carried out on populations of college students. You will notice that some different predictors are used in each. The numbers between the variables indicate the zero order correlations between the indicated variables. They have not been converted to variance accounted for, as they are in some of the diagrams furnished by Dr. Kling. We were able to run only one multiple regression analysis through the computer for each of these samples and then constructed the first iteration of a Wherry-Doolittle-Holmes method by simply indicating the three highest-ranked correlations in each case. It is possible that of the three predictors of the first order variables, one would drop out of each if we were able to carry it to completion. These limited analyses, done only for the purposes of this critique, are not carried out through the second or third step because of the expense involved. However, there is enough data here to suggest that one gets out of an analysis essentially what he puts into it. We have known this for some time about factor analysis, but the point has not been

made, so far as I know, with sub-strata analysis.

I could not resist renaming the variables much in the manner of the California theorists. As you probably know, "Power of Reading" usually turns out to be a subtest; on some existing test of reading comprehension. In one case it was a Gates subtest, and as I understand it, in another case, it was a subtest of the Van Wagenen. The criterion on the two multiple regression analyses in Figures 1 and 2 is grade point average, renamed "Power of Performance." One of the interesting things that grows out of the comparison of these two analyses is the fact that in one case personality variables came out as one of the predictors. This, of course, was because personality variables were put in it in the first place. That, "defense systems," variable is the L, or lie score on the Minnesota Multiphasic Personality Inventory. The fact that this variable turns up at the first level inevitably determines that all of those personality measures which are highly correlated with it will turn up later in the analysis. If it had been possible for us to carry this out to the third step, I am sure we would have found almost all of the variables from the MMPI showing up as predictors in later "subsystems." One of the reasons I bring this up is Kling's concluding statement that "sub-abilities make significant contributions to the variables immediately preceeding them and to the major criterion itself." A look at any one of the Holmes and Singer papers, either of the analyses reported in the Kling paper, or either of the analyses in Figure 1 and 2 would seem to me to indicate that this is not true. In fact, if it were true, these would not be second-order predictors but would have contributed significantly to the explanation of the original variance and would be included in the first iteration. This is a particularly important point since it seems to me to indicate one of the major criticisms of this kind of analysis. The reason that Wherry and Doolittle proposed dropping out those variables which did not significantly add to prediction of the criterion was that they did not make a significant contribution to it.

I think it is extremely important to recognize the need for replication of substrata analysis if it is to be taken seriously. I may have missed an article somewhere by Holmes, Singer, or Kling, but I have seen no reference to any analysis in which the same criteria were predicted using the same instruments on different populations. I cannot over-emphasize the importance of such replication.

Possibly I can make my point by example. Supposing I were to take the data provided in the original table of intercorrelations on Power of Reading and to throw all of the tally sheets up a stairway - thus ordering the variables in what would probably be a chance order. Supposing then that I were to take the ones on each step as a separate group and throw them up several other stairway - ordering them again according to the step they fell on. I could do this, if I had enough stairways, for two, or three, or possibly four iterations and I would end up with a great deal of data, representing an after-the-fact organization of the data at hand. I would have no way of knowing whether or not I would get the same distributions of variables if I took a sample of people from another population and used the same variables and the same stairways. Until we get a cross-validation using a similar population with the same criterion and the same predictors, we will be in a very similar position with regard to the Wherry-Doolittle-Holmes substrata factor theory.

So much for the statistics. I would like to make a few comments about the paper in general and its relationship to the scientific method. Probably the most widely accepted notion of the nature of science is that its purpose is to predict and control events. It seems to me that there are two reasons for doing the sort of thing that is reported in Kling's paper. One is to do science - to attempt to predict and control events. The other is to do something because it is an enjoyable pastime - a sort of mental gymnastic. If it is an effort at doing science, it probably has something to say to us in terms of outcomes. However, I fail to see anything in this particular way of approaching data that does very much for us in terms of suggesting appropriate experimental designs. Theoretical models are of use to us only if they produce research which in turn is useful to us. The models themselves never produce data. Only experimental results based on the theory from the models actually produce new knowledge. In this case, I wonder what we are to gain by this information about shared variance. Simply because a variable shares some variance with another variable does not necessarily mean that a change in one will produce a change in another. In the example given first in the Kling paper, if we are to assume that this is somehow a description of the nature of reality, rather than simply some fun and games with numbers, I guess we would have to assume that since the variable Arithmetic Reasoning came out as one of the first factors and

English Literature didn't come out until the second iteration, this means that if we were to improve arithmetic reasoning we would then improve power of reading, and that we would do more for power of reading than if we were to teach English literature. I resist very much talking about the data in this way because, it seems to me, to represent a very long leap across the chasm that separates science from metaphysics. However, I do not see any other interpretation of the data that would enable us to take any scientific advantage of it.

I think it is extremely important to keep in mind two fundamental questions when we talk about theoretical models. The first one is What action does the model suggest? - in other words, what exactly does it tell us to do? The second question is What evidence is there that these actions work? Until we get the answer to both of these questions, it seems to me we are in no position to evaluate the utility of any theoretical model.

I would like to summarize my remarks about the substrata factor theory of reading by quoting briefly from an article written by B. F. Skinner, based on a lecture given at the University of Pittsburgh in January, 1958. In this speech he was concerned about what he called the "Flight from the Laboratory."¹

"Some psychologists have fled to an ivory image of their own sculpturing, mounted on a mathematical pedestal. These Pygmalions have constructed a Galatea who always behaves as she is supposed to behave, whose processes are orderly and relatively simple, and to whose behavior the most elegant of mathematical procedures may be applied. She is a creature whose slightest blemish can be erased by the simple expedient of changing an assumption. Just as political scientists used to simplify their problems by talking about an abstract Political Man, and the economists theirs by talking about Economic Man, so psychologists have built the ideal experimental organism - the Mathematical Model....

No matter how many of the formulations derived from the study of a model eventually prove useful in describing reality (remember wave-mechanics!), the questions to which

answers are most urgently needed concern the correspondence between the two realms. How can we be sure that a model is a model of behavior? What is behavior, and how is it to be analyzed and measured? What are the relevant features of the environment, and how are they to be measured and controlled? The answers to these questions cannot be found by constructing models....

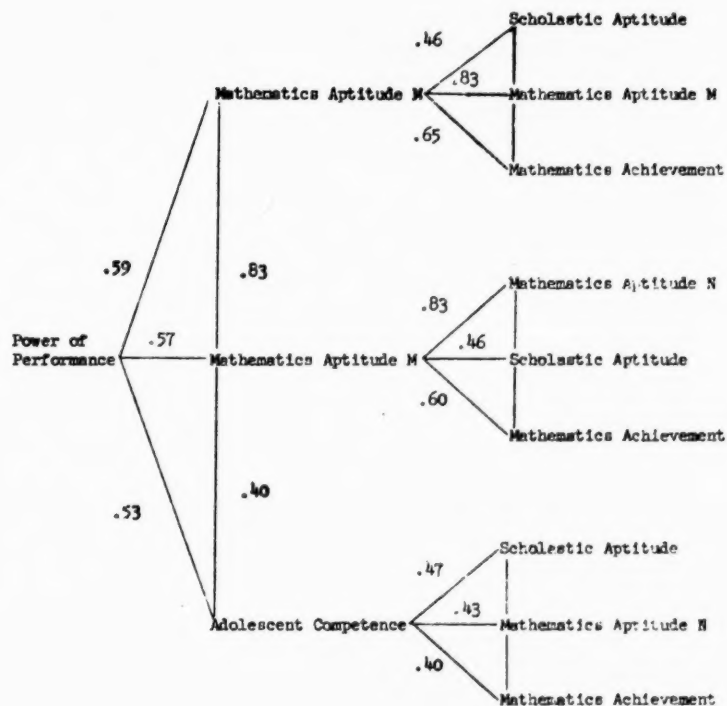
What is needed is not a mathematical model, constructed with little regard for the fundamental dimensions of behavior, but a mathematical treatment of experimental data. Mathematics will come into its own in the analysis of behavior when appropriate methods yield data which are so orderly that there is no longer any need to escape to a dream world."

¹Skinner, B. F., Cumulative Record, New York: Appleton-Century-Crofts, Inc. p. 250-252, 1959.

Wherry Doolittle Multiple Regression Analysis

Figure 1

N = 406



Criterion:

Power of Performance

Predictors:

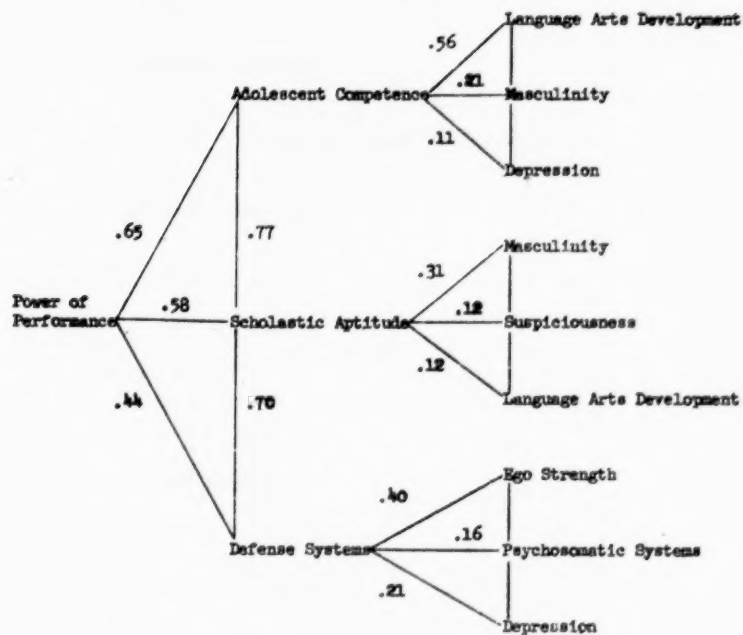
Adolescent Competence
Mathematics Aptitude N
Mathematics Aptitude M
Mathematics Achievement

Alton L. Baygor
University of Minnesota

Wherry Doolittle Multiple Regression Analysis

Figure 2

N = 260



Criterion:

Power of Performance

Predictors:

Hysterical Conversion	Rebelliousness
Adolescent Competence	Language Arts Development
Psychosomatic Systems	Honesty
Scholastic Aptitude	Ego Strength
Depression	Masculinity
Defense Systems	Suspiciousness
Togetherness	Psychasthenia
Separateness	Energy Level

Alton L. Raygor
University of Minnesota

A CRITIQUE OF
"GENERAL OPEN SYSTEMS THEORY
AND THE
SUBSTRATA-FACTOR THEORY OF READING"

Donald E. P. Smith

University of Michigan

Open systems theory is a theory about open systems. Systems, by definition, have parts called sub-systems and these sub-systems, in turn, commonly have sub-systems. Sub-strata factor theory describes the cognitive structure of the reader as a system with sub-systems, etc. Thus, Kling says, systems theory and sub-strata theory are similar. They're both theories and they're both concerned with systems. We certainly can't argue with that reasoning.

The Holmes and Singer's sub-strata factor theory is worthy of careful study. The concept of a hierarchical structure of skills is a seminal one. We have used such a conception in analyzing language skills in our laboratory at Michigan. For example, we found that sub-skills in manuscript writing include discrimination of form, discrimination of points in space, and a motor component. Writing, then, may be described as the imposition of letter forms on space. The visual components together account for twelve times as much variance as the motor component. Thus, our instructional programs in manuscript and cursive writing are primarily visual-discrimination exercises which produce orthography many times more efficiently than do standard handwriting practices.

The hierarchical concept of sub-strata theory is useful. Furthermore, the statistical procedures developed to reveal the structure appear to me to be sound. But, as Raygor points out, one must be clever about the skills selected for the analysis. No factor analysis will derive protein, carbohydrates, and fats from whole tissue.

Thus, my only quarrel with the present explication of the theory is the selection of tests. For example, Kling reports a relationship between a score on a civics test and "Power of Reading". Am I then to conclude that knowledge of civics is a sub-strata factor? If so, I should teach civics in order to increase "Power of Reading." This conclusion strains my credulity.

On the other hand, Holmes' earlier analyses using auditory components (pitch, tempo, etc.) looked promising. Other components in the visual sphere also look good: length and direction of line; continuity of line; points in space; closure; and others. It looks to me as though the sub-strata theory itself is sound for ordering skills. Now it needs some skills to order.

SELECTED REFERENCES

- Black, Max. Models and Metaphors. Ithaca, New York: Cornell University Press, 1962.
- Braithwaite, R. B. Scientific Explanation. Cambridge, England: Cambridge University Press, 1955.
- Brodbeck, May. "Models, Meaning and Theories," in Symposium on Sociological Theory. Llewellyn Gross (ed.), Evanston: Row, Peterson & Company, 1959.
- George, F. H. "Models and Theories in Social Psychology," Symposium on Sociological Theory. Llewellyn Gross (ed.), Evanston: Row, Peterson & Company, 1959.
- Kingston, Albert J. "A Conceptual Model of Reading Comprehension," Phases of College and Other Adult Reading Programs, Milwaukee: Marquette University Reading Center, 1961.
- Meadows, Paul. "Models, Systems, and Science," American Sociological Review, vol. 22, Feb. 1957, 3-9.
- Nagel, Ernest. The Structure of Science. New York: Harcourt, Brace and World, 1961.
- Restle, Frank. "The Relevance of Mathematical Models for Education in Theories of Learning and Instruction," Ernest R. Hilgard, (ed.), 111-132, Part I, The Sixty-Third Yearbook of the National Society For The Study of Education. Chicago: University of Chicago Press, 1964.
- Von Bertalanffy, Ludwig. "An Outline of General System Theory," The British Journal For the Philosophy of Science. vol. I, May, 1950. 134-165.

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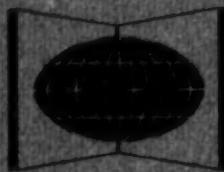
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